THE UNIVERSITY OF ALBERTA

SEDIMENT TRANSPORT MEASUREMENTS

by

(C) GERALD WALTER SAMIDE, B.Sc. ENG.,
(University of Alberta, Edmonton)

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

DEPARTMENT OF CIVIL ENGINEERING

EDMONTON, ALBERTA

FALL, 1971

ABSTRACT

Sediment transport measurements were taken on the Elbow River at Bragg Creek, the North Saskatchewan River at Nordegg and the North Saskatchewan River at Wilson's Bridge. The Elbow River site was studied previously by A. B. Hollingshead in 1967 and 1968.

Bed-load discharge was measured with three different portable bed-load samplers at Nordegg and Bragg Creek. These samplers were the 1/4 inch mesh basket, the 1/2 inch mesh basket and the V.U.V. samplers. Bed-load discharge was also determined by direct measurements on the refilling rate of a large pit excavated in the Elbow River bed. Suspended sediment measurements were carried out at all three sites using depth-integrating samplers. The velocity distribution was measured for several different stages of flow. A hydrophone was used to determine the start and width of bed-load movement.

The efficiency of the 1/4 inch mesh basket was determined for certain low flows on the Elbow River. Relative sampling efficiencies between the bed-load samplers were determined with the most efficient sampler being the 1/2 inch mesh basket. The bed-load discharge obtained from bed-load sampling was related to fluid discharge. Bed material discharge was determined using graphs which were developed by Cooper and Peterson (1968). The calculated bed material discharge was then compared with measured bed-load discharge. The bed-load material was analyzed for size-distribution and compared to the size-distribution obtained from bed-load samples.

The relationship between suspended sediment discharge and bed-load discharge was calculated for Bragg Creek and for Nordegg. The total sediment yield at all three sites was determined.

A statistical study on bed-load movement is recommended for Bragg Creek. An efficient method of measuring the refilling rates of a large volumetric pit would enable the exact determination of bed-load sampler efficiencies.

ACKNOWLEDGEMENTS

The study described was undertaken jointly by the Water Survey of Canada and the Alberta Cooperative Research Program in Highway and River Engineering. The latter program includes as participating bodies the Research Council of Alberta, the Department of Civil Engineering, University of Alberta, the Division of Water Resources of the Provincial Department of Agriculture and the Provincial Department of Highways and Transport.

Acknowledgements are expressed to Professor A. W. Peterson and Dr. R. H. Cooper, University of Alberta; Mr. A. B. Hollingshead and Mr. C. R. Neill, Research Council of Alberta; Mr. E. Yaremko, Provincial Water Resources Division; Mr. N. Tywoniuk and all the staff in the Calgary office of Water Survey of Canada for their assistance in this research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER IV - (Cont'd.)

Appendix B

CHAPTER IV - (Cont'd.)

CHAPTER V

LIST OF PHOTOGRAPHS

CHAPTER I

INTRODUCTION

1.1 Reasons for the Study

Sediment can create problems in water power development, water supply, navigation, flood control, loss of reservoir storage capacity, irrigation, land damage, and soil conservation. Because of its importance, engineers are beginning to look at rivers as streams of sediment as well as streams of water.

Sediment load is the sediment that is being moved down the river and can be generally divided up in the following way:

Sediment Load

Wash Load consists of fine grains which have washed off the drainage basin and are finer than the stream bed material

Bed Material Load made up of grain sizes found in appreciable quantities in the bed.

Suspended Sediment - that part of the sediment load that is in suspension

Bed-Load - that part of the sediment that is transported by rolling, sliding or skipping along the bed

It can be seen from above, that sediment transported by a stream may conveniently be divided into suspended load and bed-load; but depending on the flow conditions, sediment may at one time be part suspended load and at another time part bed-load. For this study bed-load will be defined as that measured with bed-load samplers and suspended

load that which is measured with suspended sediment samplers.

1.2 Objects of the Study

The object of this study was to determine the amount of bed-load discharge in two gravel rivers using portable samplers and in so doing answer the following questions.

1. What are the efficiencies of the various portable bed-load samplers used, when compared to actual bed-load discharge?
2. How do the various bed-load samplers compare as to
   (a) different size range of material caught?
   (b) relative efficiencies?
3. How do field bed-load measurements compare with graphs on bed material discharge obtained by Cooper and Peterson (1968) from an analysis of world flume data.
4. What are the hydraulic conditions for first displacement or incipient motion?
5. For each study site, is there a relation between the amount of suspended sediment and the amount of sediment classed as bed-load.
6. How does sampling from a cableway with a cable car compare to sampling from a bridge with a truck-crane?

This report will also provide useful field data for anyone studying sediment transport.

CHAPTER II

THEORY

2.1 Bed-Load Samplers

Bed-load discharges can be determined from measurements taken with portable bed-load samplers which collect the bed-load discharge from a narrow width of the stream bed. The ratio of material caught by a bed-load sampler to actual bed-load transport is known as the efficiency of that bed-load sampler. However, the efficiencies will vary with any or all of the following factors: velocity, depth, particle size, bed-load magnitude, degree of filling and bed configuration.

Besides variable and uncertain efficiencies, another major factor that causes inaccuracy in bed-load sampling is the fact that bed-load discharges vary rapidly and erratically with time. Therefore numerous samples are required at one point in order to establish a representative transport rate. This in turn causes another possible error, that is that during the time required to obtain these numerous samples, the flow conditions can change and therefore the results may not correspond to the correct flow conditions.

Tests have been made to calibrate the various samplers according to sample efficiency and hydraulic efficiency (Hubbel 1964) (Hollingshead 1967 and 1968). The results are questionable for most of the tests were run in the laboratory flumes where it is rather difficult to model

sediment movement and other relevant hydraulic factors. Efficiencies that were obtained from actual test rivers were for rivers which had sand bed material. The rivers which were sampled in this report are rivers which have gravel for bed material. Hollingshead (1967 and 1968) obtained bed-load sampler efficiencies on gravel rivers for low flows by comparing results of bed-load samplers with results obtained from a volumetric pit.

2.2 Bed-Load Determination from Volumetric Pit

Volumetric pits are placed in the stream bed by excavating the bed material to some depth. This results in a larger cross sectional area through which the water must flow. Therefore the velocity of the water is lowered and the bed-load discharge is trapped by the pit. The main advantages of the volumetric pit is that it is capable of collecting nearly 100% of the bed-load. However, they are costly and difficult to survey at high flows.

2.3 Available Experimental Data

Cooper and Peterson 1968, analyzed most of the available experimental flume data on bed material transport with the aid of a computer. Their analysis consisted of an evaluation of a set of independent functional equations describing those aspects of the phenomenon most frequently encountered in practice. Results were presented in the form of non-dimensional contoured plots.

With the help of Dimensional Analysis, functional expressions relating both C and h/D_{50} to V_m^2/gh and S respectively were developed by

the authors. They also verified that the effect of b/h is small for values greater than 5.0. In their analysis, density ratio of solids to fluid ρ_s/ρ_f has been eliminated and their results are only applicable to situations where G_s is constant and equals 2.65. They also suggest that the effect of gradation is small.

2.4 Relation of Bed-Load Discharge to Suspended Sediment

The quantity of bed-load as compared to suspended load has been studied by various people. Altunin (Walenty Jarocki 1967) found that for rivers in central Asia the ratio of bed-load discharge to suspended sediment discharge was 15-23% in mountain streams, 5-15% in hilly streams and 1-3% on the plains. In U.S.S.R., Lopatin (Walenty Jarocki 1967) found that the ratio of bed-load to suspended load was about 0.05 to 0.10 for rivers on the plains and from 0.10 to 0.20 for mountain streams. These relationships are based on the average results of bed-load and suspended sediment measurements. Comparison of instantaneous measurements taken reveal a discrepancy in the ratio between suspended sediment and bed-load discharge. The explanation of this discrepancy lies in the fact that the quantity of suspended sediment discharge and bed-load discharge fluctuate with time. Other factors which attribute to this discrepancy are local scouring of the bed and banks, precipitation, migration of the channel in the river valley, etc.

Jarocki (1967), from his study on Polish Rivers, states that the quantity of bed-load discharge is always less than suspended load and that there is a correlation between the two.

2.5 Fluctuations in Bed-Load Discharge Analyzed Statistically

Statistical analysis of bed-load movement has been done by B. S. Shteynman (1966) on the Kura River in Poland. Shteynman derived bed-load movements from a large number of bed-load samples. On the basis of the integral limiting theorem of probability, he found that the fluctuations in the derived bed-load movement conformed to the Gaussian law of distribution. Knowing the distribution, Shteynman then established confidence limits for his results. Shteynman also declared that for the rivers they sampled, the average of 20 samples was the same as the average for 100 samples. These bed-load measurements were obtained from the Kura River which has sand dunes for bed forms. Therefore these results do not necessarily apply for a gravel river where the bed forms are not known.

CHAPTER III

EQUIPMENT AND METHODS

3.1 Introduction

Most of the equipment and methods used in this study are the same as those used in the Hollingshead study of 1967 and 1968. Therefore descriptions of the equipment and methods will be brief with emphasis on any new equipment or methods.

3.2 Basket and V.U.V. Samplers

The Basket and V.U.V. bed-load samplers were the same as those used in the 1967 study by Hollingshead, only the 3/4" mesh basket was not used. PLATES NO. III-1 and III-2 show the basket and V.U.V. bed-load samplers respectively.

3.3 Bed-Load Discharge Sampling

(a) Bragg Creek

Sampling was carried out from a cableway which crosses the Elbow River near the Village of Bragg Creek.

The sampling was done from a mechanized cable car (see PLATE NO. III-3). PLATES NO. III-4 through to PLATE NO. III-6 show the power winch used for raising and lowering the samplers, the mechanism for lateral movement, and the weigh scale.

Located approximately 50 feet upstream of the main cableway was another cableway parallel to the main cableway (see PLATE NO. III-7). This smaller cableway will be referred to as a "stay line" in the remainder of this study. This stay line was stretched across the width of the river 2 feet above high water level. A rope ran from the cable car out to the stay line and back to a bed-load sampler (see PLATE NO. III-7). This rope shall be referred to as the "stay rope" for the remainder of this study.

(b) Nordegg

Sampling at Nordegg was carried out from a bridge which crossed over the North Saskatchewan River near the Village of Nordegg. At Nordegg, sampling was done using a truck that was equipped with a crane and power winch. The truck used was a 1969 Ford which had a gross vehicle weight of 22,000 pounds. The hydraulic crane (shown fully extended on PLATE NO. III-8) had the following capacities:

8000 pounds at 5'	radius
5000 pounds at 8'	radius
3670 pounds at 11'	radius
2420 pounds at 16 1/2'	radius

Located about 150 feet upstream from the bridge was a stay line which ran parallel to the bridge. The stay line stretched across the river and was about 1 foot above high water level at its lowest point. The stay line was equipped with a stay rope the same as Bragg Creek, however, one end of the rope was attached to a bridge instead of a cable car.

The procedure for sampling with Basket Samplers is as follows:

1. Attach the desired bed-load sampler to the power winch.

2. Move to the desired location.
3. Lower the sampler till it is just above water level.
4. Tighten the stay rope.
5. Lower sampler to river bottom.
6. When the sampler is on the bottom start stop watch and loosen stay rope.
7. Anticipate the sampling time required to trap approximately 100 lbs. of sample.
8. Before pulling up sample tighten stay rope.
9. Raise and weight sample.
10. Record location, time and weight.
11. Dump sample back into river.

The stay rope is required because the sampler has a tendency to move downstream due to the drag created by the moving water. The stay rope keeps the sampler from moving downstream. When the sampler is on the bottom the stay rope can be loosened because the lower velocities near the bottom produce smaller drag forces. If the tension in the stay rope was not released during sampling, the front end of the sampler would lift up and bed-load discharge would pass under the lip of the sampler.

When the V.U.V. sampler was used in the same way that the Basket sampler was used, it refused to sink to the bottom and planed the water surface. In order to get the V.U.V. to sink, a rope was tied to the rear of the sampler and kept tight while the V.U.V. was being lowered into the water. This made the sampler tilt forward and caused the sampler to dive downwards into the water. (See PLATES NO. III-9,

III-10 and III-11.) Once the sampler was on the bottom the rear rope was let loose and sampling proceeded in the usual manner.

Not all samples were dumped back into the river, some were saved and analyzed for size at a later date.

3.4 Hydrophone

Two different hydrophones were used in this study. The one used in 1967 by Hollingshead (1967) and a smaller more compact model that was used in 1968. Both hydrophones operate on the same principle; the only difference between them being their size and weight. One weighs 35 pounds while the other weighs 87 pounds.

With the use of the hydrophone it was possible to listen to the sound of the moving gravel. Because this sound of gravel movement can be detected, the width of the moving strip and competent conditions can also be detected.

An attempt was made to relate the level of sound to a quantitative measure of bed-load discharge using a recorder which recorded electrical output from the hydrophone. This has been attempted using a similar type of equipment and was reported by Hubbel (1964). The results will be discussed in a later section.

3.5 Bed-Load Determination Using Pit Excavation

Almost all of the total bed-load movement on the Elbow River at the Bragg Creek site occurs on the left side of the channel (as reported by Hollingshead 1968). The pit which was 200 feet long by 70 feet wide by three feet deep, was located along the left side of the river. Rough

estimates suggested that the pit was capable of trapping 1,000 cubic yards of material with 100% efficiency. Thereafter the efficiency would decrease. The pit was surveyed using a cross-section every 10 feet along its length. These cross-sections were taken from a small car top boat held stable in the river with three guide ropes.

The pit was resurveyed after flows above competent conditions had occurred so that the volume of bed-load discharge could be determined.

3.6 Velocity Measurements and Equipment

The velocity measurements necessary for discharge calculations were carried out at both Bragg Creek and Nordegg using a Gurley current meter. Besides these velocity measurements, additional measurements were taken using a Gurley meter attached so that it was six inches above the sounding weight. The above measurements were taken at least once a day on those days when bed-load movement was occurring.

In order to get measurements of velocity closer to the bed than 0.5 feet, a velocity rake was built (see PLATES NO. III-12 and III-13). The rake consisted of 5 pigmy meters, 1 Gurley meter, 6 counters, a power source, a stabilizer fin and two thirty pound weights. With this device it was possible to obtain velocities to within 0.2 feet of the river bed. Also the velocity rake read six velocities at the same time. This meant all velocity meters were recording over the same time interval and therefore a better time-wise average was obtained.

3.7 Bed Material Sampling

In order to determine the size of the bed material, pit samples

were taken from gravel bars at both sites and from the volumetric pit at Bragg Creek. For these samples an area was marked out and all the material within this area was excavated to the depth of the largest particle.

3.8 Suspended Sediment Measurements

Suspended sediment samples were taken on the Elbow River at Bragg Creek, the North Saskatchewan River at Nordegg and the North Saskatchewan River at Wilson's Bridge. At low water stages, the depth-integrating wading hand sampler (US DH-48) and the depth-integrating hand-line sampler (US DH-49) were used. At high water stages the depth-integrating sampler, US D-49 was used. PLATE NO. III-14 shows a photograph of the US D-49 depth-integrating sampler.

CHAPTER IV

FIELD OBSERVATIONS AND RESULTS

4.1 The Study Areas

Two sites were selected for this study. These sites were Bragg Creek on the Elbow River located 30 miles southwest of Calgary and Nordegg Bridge on the North Saskatchewan River located about 100 miles west of Red Deer. These locations are designated study areas (1) and (2) respectively on FIGURE 4-1. The Bragg Creek area had been previously studied by Van Der Geissen 1966 and Hollingshead 1967. The reason for the Bragg Creek site being selected again was because of access, the presence of existing available equipment and the information already obtained on bed-load movement. The Nordegg Site was selected because of the large number of days per year over which bed-load movement was known to occur.

4.2 Hydrologic Data

(a) Elbow River

The Elbow River Drainage Basin is shown on FIGURE 4-2. This figure shows that the basin is composed of foothills and mountains. The basin at Bragg Creek drains approximately 306 square miles.

Water Survey of Canada have a water stage recorder on the Elbow River, located 100 feet downstream of the existing bridge. The recorder

has been in operation for 33 years. From these records the mean flow is approximately 390 c.f.s. From the flood-frequency curve of FIGURE 4-3 the 1 in 10 year mean daily flood is 4,850 c.f.s. and the 1 in 100 year mean daily flood is 10,000 c.f.s.

Hydrographs of mean daily discharge for the years of 1967, 1968 and 1969 are plotted on FIGURES 4-4 and 4-5. FIGURE 4-6 shows a flow-duration curve for the Elbow River at Bragg Creek. FIGURE 4-7 shows the Stage-Discharge rating curves at Bragg Creek. The instability of the stage-discharge curves is usually caused by bars passing down the river and/or channel shifts.

(b) North Saskatchewan River

The North Saskatchewan River Basin, shown on FIGURE 4-8, is divided into the following drainage areas and are as follows:

Area	Location	Drainage Area
1	Saunders	1,980 square miles
2	Nordegg	1,755 square miles
3	Tershishner Creek	1,430 square miles
4	Wilson's Bridge	642 square miles
5	Saskatchewan Crossing	492 square miles

Water Survey of Canada have kept records of discharge at Saunders, Tershishner Creek and Saskatchewan Crossing. Since there are no flow records at Nordegg, it was necessary to estimate flows from records at Saunders and Tershishner Creek. The mean daily flow at Nordegg is 5,800 c.f.s. The 1 in 10 year mean daily flood is 20,300 c.f.s. and the 1 in 100 year mean daily flood is 24,700 c.f.s. FIGURES 4-9 and 4-10 show the flood frequency curves at Saunders and Tershishner Creek respectively.

The hydrograph of mean daily discharge for Nordegg (1969) is shown on FIGURE 4-11. Flow duration curves for Saunders, Nordegg, Tershishner Creek, Wilson's Bridge, and Saskatchewan Crossing are shown on FIGURE 4-12. The flow duration curves for Nordegg and Wilson's Bridge were obtained by interpolation based on area of drainage basin.

The stage-discharge curve for the North Saskatchewan River at Nordegg (as shown on FIGURE 4-13) was very unstable and very flat (i.e. small change in water elevation resulted in large change in discharge). Curve #1 of the stage-discharge curves was used up till July 10, 1969, and curve #2 was used after July 10, 1969. The change in curves was caused by a channel shift immediately upstream from Nordegg Bridge.

4.3 Channel Geometry

(a) Elbow River at Bragg Creek

The channel geometry was described in the study done by Hollingshead in 1967. It was found that the channel has not changed much since then and that the cross-sections taken in 1967 would be adequate for use in this study.

(b) North Saskatchewan River at Nordegg

PLATE NO. IV-1 taken in 1969 shows the bridge and reach of the river where the study was carried out. Cross-sections were taken along this reach in the summer of 1968 and in the spring of 1969, and are on file with the Highways Division of the Research Council.

The location of the main channel in the fall of 1968 and the spring of 1969 is shown on PLATE NO. IV-2. The channel at that time was

approximately parallel to the guide bank. PLATE NO. IV-3 shows the main channel after the high flows which occurred in the month of June, 1969. The channel has now shifted and the main channel flow is now flowing directly at the nose of the guide bank.

FIGURE 4-14 shows the cross-sections which were taken at various times (beneath the bridge structure).

4.4 Slope Observations

(a) Bragg Creek

A staff gauge was set up at the cableway, located 1800 feet downstream from the permanent stage recorder. The staff gauge was read periodically and the time of reading and water elevation noted. Knowing the water elevation at the recorder and at the staff gauge a surface water slope was calculated. The average slope was about 7.45×10^{-3} which was the same as obtained by Hollingshead (1967).

(b) Nordegg

FIGURE 4-15 shows the water profiles that were taken on the North Saskatchewan River at Nordegg. From the water profiles the average slope is about 1.58×10^{-3}.

4.5 Velocity Observations

(a) Elbow River

Velocity distributions and profiles were obtained on the Elbow River using the previously described velocity rake. These distributions are shown on FIGURE 4-16 and 4-17 for flows of 880 c.f.s. and 1,090 c.f.s.

respectively. An attempt was made to obtain velocity distributions at flows higher than 1,090, using the velocity rake. However, at these flows the moving bed-load damages the pigmy meters to such an extent that they are no longer useable. Therefore for flows above competent conditions the Gurley current meter and sounding weight was used. With the Gurley current meter, velocities were obtained at either 0.6d or 0.2d and 0.8d depending on the depth at each station. Velocities were also obtained at a point 6 inches off the river bed. From these velocities and knowing the approximate shape of a typical velocity profile, a velocity distribution was drawn for a flow of 3,290 c.f.s. (see FIGURE 4-18).

FIGURES 4-19 through to FIGURE 4-27 are plots of the velocity profiles on semi-log paper. These profiles were obtained directly from the results of the velocity rake for fluid discharges of 880 c.f.s. and 1,060 c.f.s. The velocity profile for a fluid discharge of 3,290 c.f.s. was obtained from the velocity distribution diagram of FIGURE 4-18.

(b) North Saskatchewan River

The velocity rake was not used at Nordegg because the flow was always above competent conditions during sampling operations. The velocity distributions are shown on FIGURES 4-28 and 4-29 for discharges equal to 11,900 c.f.s. and 6,800 c.f.s. respectively. These distributions were obtained using a Gurley meter as previously described.

4.6 Bed-Load Discharge Sampling

TABLES IV-1 and IV-2 located in Appendix A gives the observations of all bed-load measurements obtained on the Elbow River and the North

Saskatchewan River respectively. Column one gives the identification number of the bed-load sample. Column two is the date when the sample was taken. Column three is the station where the sample was taken; the station being referenced to the lateral distance from the datum point on the left bank. Column four gives the type of bed-load sampler used to obtain the sample. Column five and six give the sampling time and the sample weight respectively. Columns seven and eight represent the mean water depth and the mean velocity respectively at that station. Column nine gives the average fluid discharge in the river when the sample was taken. Column ten lists the number given to a sample that was saved for grain size analysis, which will be discussed later on. Column eleven is the mean diameter obtained from the size analysis.

4.7 Analysis of Bed Material and Bed-Load Sampled Material

TABLE IV-3 and TABLE IV-4 show the results of size analysis on samples obtained from Elbow River and North Saskatchewan River respectively. Column one in the tables gives the sample number. Column two gives the type of sample. Column three in the tables gives the location of where the sample was obtained. If the type of sample was a pit sample then it will be referenced according to its location either upstream or downstream from the road bridge. If the sample was obtained from a bed-load sampler, then the location will be referenced according to the datum point on the left bank and the station is the distance laterally in feet across the stream. In the case of Volumetric Pit samples taken at Bragg Creek, column three includes the distance laterally from the datum point. The rest of the columns give the percent of

TABLE IV-3

SIZE DISTRIBUTION OF BED MATERIAL AND BED-LOAD SAMPLES
ELBOW RIVER AT BRAGG CREEK

SAMPLE NO.	TYPE OF SAMPLE	LOCATION	PERCENTAGE RETAINED BY 8"	5"	3"	2"	1 1/2"	1"	3/4"	3/8"	#4	#10	#20	#40	#100	#200
1	Pit Sample	11+00 D/S	31	40	46	55	61	68	74	85	92	95	96	97	100	--
2	Pit Sample	3+00 D/S	--	--	34	46	54	64	73	83	88	92	93	96	99	100
3	Pit Sample	1+00 D/S	--	--	19	32	42	57	67	82	90	93	95	96	99	100
4	Pit Sample	11+50 D/S	--	--	4	8	31	46	54	72	81	86	92	96	99	100
5	Large Basket 1/4" Mesh	Sta 50	--	--	--	--	--	12	30	71	94	99	100	--	--	--
6	Large Basket 1/4" Mesh	Sta 60	--	--	--	33	50	76	86	98	100	--	--	--	--	--
7	Large Basket 1/2" Mesh	Sta 50	--	--	--	1	3	9	27	63	86	94	100	--	--	--
8	Large Basket 1/2" Mesh	Sta 60	--	--	--	39	55	82	90	98	100	--	--	--	--	--
9	Large Basket 1/2" Mesh	Sta 70	--	--	--	66	75	86	93	99	100	--	--	--	--	--
10	Large Basket 1/4" Mesh	Sta 50	--	--	--	1	2	5	10	31	63	82	96	99	100	--
11	Large Basket 1/4" Mesh	Sta 65	--	--	25	[illegible]	64	80	90	98	100	--	--	--	--	--
12	Large Basket 1/2" Mesh	Sta 80	--	--	20	44	58	84	98	100	--	--	--	--	--	--
13	V.U.V.	Sta 60	--	--	20	26	35	50	66	87	96	100	--	--		--
14	Large Basket 1/4" Mesh	Sta 80	--	--	28	55	74	88	94	99	100	--	--	--		--
15	Large Basket 1/4" Mesh	Sta 60	--	--	7	22	40	60	76	94	100	--	--	--		--
16	Large Basket 1/4" Mesh	Sta 70	--	--	16	50	70	90	97	100	--	--	--	--		--
17	Large Basket 1/4" Mesh	Sta 80	--	--	25	50	65	80	90	99	100	--	--	--		--
18	Large Basket 1/4" Mesh	Sta 50	--	--	5	20	40	60	74	91	98	100	--	--		--
19	Large Basket 1/4" Mesh	Sta 70	--	--	50	72	81	88	91	95	100	--	--	--		--
20	Large Basket 1/4" Mesh	Sta 60	--	--	13	42	66	94	96	96	97	98	99	100	--	--
21	Large Basket 1/4" Mesh	Sta 70	--	--	17	46	67	86	93	100	--	--	--	--		--
22	Large Basket 1/4" Mesh	Sta 70	--	--	17	40	56	75	85	97	100	--	--	--		--
23	Large Basket 1/4" Mesh	Sta 60	--	--	3	9	19	40	63	92	98	100	--	--		--
24	Large Basket 1/4" Mesh	Sta 50	--	--	--	--	--	4	9	32	67	87	97	99	100	--
25	Large Basket 1/4" Mesh	Sta 60	--	--	--	20	36	60	77	94	98	100	--	--	--	--
26	Large Basket 1/4" Mesh	Sta 80	--	--	24	40	54	75	86	100	--	--	--	--	--	--
27	V.U.V.	Sta 50	--	--	--	--	--	--	--	17	42	67	90	97	98	99
28	Large Basket 1/4" Mesh	Sta 50	--	--	--	2	4	11	18	47	81	92	97	98	99	100
29	Large Basket 1/4" Mesh	Sta 50	--	--	--	1	3	10	18	41	68	88	98	100	--	--
30	Large Basket 1/4" Mesh	Sta 70	--	--	4	28	43	63	77	93	100	--	--	--	--	--
31	Large Basket 1/4" Mesh	Sta 60	--	--	--	20	36	57	72	97	100	--	--	--	--	--
32	V.U.V.	Sta 60	--	--	--	22	43	73	87	97	100	--	--	--	--	--
33	Large Basket 1/4" Mesh	Sta 80	--	--	30	58	74	88	94	98	100	--	--	--	--	--
34	Volumetric-Pit Excavated	12+30 D/S Sta 70	--	--	4	30	52	75	85	95	96	--	--	--	--	--
35	Volumetric-Pit Excavated	12+30 D/S Sta 50	--	--	1	7	17	35	50	73	83	86	90	95	98	99
36	Volumetric-Pit Excavated	13+20 D/S Sta 70	--	--	5	30	46	77	88	94	95	--	--	--	--	--
37	Volumetric-Pit Excavated	13+20 D/S Sta 50	--	--	1	10	22	40	53	82	87	89	91	95	98	100
38	Volumetric-Pit Excavated	14+00 D/S Sta 70	--	--	15	30	40	55	69	88	93	94	96	97	99	100
39	Volumetric-Pit Excavated	14+00 D/S Sta 50	--	--	1	3	6	17	32	57	72	79	87	94	98	100

TABLE IV-4

SIZE DISTRIBUTION OF BED MATERIAL AND BED-LOAD SAMPLES
NORTH SASKATCHEWAN RIVER AT NORDEGG

SAMPLE NO.	TYPE OF SAMPLE	LOCATION	PERCENTAGE RETAINED BY 3"	2"	1 1/2"	1"	3/4"	5/8"	3/8"	5/16"	1/4"	5/32"	#4	#10	#20	#40	#100
1	Large Basket 1/4" Mesh	Sta 62	5	16	--	49	55	66	93	96	97	97	--	--	--	--	--
2	Large Basket 1/4" Mesh	Sta 100	--	13	--	41	61	68	85	90	99	99	--	--	--	--	--
3	Large Basket 1/4" Mesh	Sta 120	16	26	--	61	77	80	90	93	99	99	--	--	--	--	--
4	Large Basket 1/4" Mesh	Sta 140	4	21	--	55	71	75	87	92	99	99	--	--	--	--	--
5	Large Basket 1/4" Mesh	Sta 80	--	11	--	33	--	54	--	81	--	94	--	--	--	--	--
6	Large Basket 1/4" Mesh	Sta 80	--	6	--	42	--	68	--	91	--	99	--	--	--	--	--
7	V.U.V.	Sta 65	--	12	26	33	53	--	75	--	--	--	91	97	98	99	100
8	Large Basket 1/4" Mesh	Sta 100	--	29	--	59	--	77	--	93	--	99	--	--	--	--	--
9	Large Basket 1/4" Mesh	Sta 80	--	15	--	54	--	76	--	94	--	100	--	--	--	--	--
10	Large Basket 1/4" Mesh	Sta 80	--	21	--	57	--	80	--	98	--	100	--	--	--	--	--
11	V.U.V.	Sta 80	--	22	41	[illegible]	83	--	94	--	--	--	96	97	97	98	100
12	Large Basket 1/4" Mesh	Sta 80	--	12	--	23	--	59	--	89	--	99	--	--	--	--	--
13	Large Basket 1/4" Mesh	Sta 100	--	2	--	46	--	76	--	98	--	99	--	--	--	--	--
14	Large Basket 1/4" Mesh	Sta 80	--	--	--	16	--	40	--	82	--	100	--	--	--	--	--
15	Large Basket 1/4" Mesh	Sta 100	--	5	--	31	--	60	--	88	--	99	--	--	--	--	--
16	Large Basket 1/4" Mesh	Sta 100	--	--	--	14	--	40	--	77	--	99	--	--	--	--	--
17	V.U.V.	Sta 100	--	8	10	[illegible]	33	--	47	--	--	--	54	57	58	75	97
18	V.U.V.	Sta 100	--	--	2	10	20	--	50	--	--	--	62	64	70	83	97
19	V.U.V.	Sta 120	--	--	--	[illegible]	1	--	1	--	--	--	2	3	5	70	100
20	V.U.V.	Sta 130	--	14	18	21	42	--	56	--	--	--	63	66	67	77	100
21	Large Basket 1/4" Mesh	Sta 100	--	21	--	60	--	79	--	89	--	99	--	--	--	--	--
22	Large Basket 1/4" Mesh	Sta 120	--	8	--	46	--	75	--	94	--	99	--	--	--	--	--
23	Large Basket 1/4" Mesh	Sta 160	--	10	--	45	--	71	--	93	--	99	--	--	--	--	--
24	Large Basket 1/4" Mesh	Sta 120	--	7	--	47	--	71	--	95	--	99	--	--	--	--	--
25	Large Basket 1/4" Mesh	Sta 120	--	10	--	38	--	63	--	89	--	99	--	--	--	--	--
26	Large Basket 1/4" Mesh	Sta 120	--	6	--	44	--	71	--	94	--	99	--	--	--	--	--
27	V.U.V.	Sta 120	6	13	20	[illegible]	64	--	88	--	--	--	97	--	--	--	--
28	V.U.V.	Sta 120	8	18	34	54	68	--	94	--	--	--	99	--	--	--	--
29	V.U.V.	Sta 120	8	16	30	[illegible]	62	--	89	--	--	--	98	--	--	--	--
30	V.U.V.	Sta 120	13	18	24	[illegible]	56	--	83	--	--	--	95	--	--	--	--
31	V.U.V.	Sta 120	7	14	26	44	58	--	83	--	--	--	97	--	--	--	--
32	Large Basket 1/2" Mesh	Sta 120	--	7	--	30	--	65	--	95	--	99	--	--	--	--	--
33	Large Basket 1/2" Mesh	Sta 120	--	7	--	[illegible]	--	72	--	95	--	99.5	--	--	--	--	--
34	Large Basket 1/2" Mesh	Sta 120	--	20	--	46	--	71	--	96	--	99.5	--	--	--	--	--
35	Large Basket 1/2" Mesh	Sta 140	--	13	--	33	--	66	--	92	--	100	--	--	--	--	--
36	Large Basket 1/4" Mesh	Sta 120	--	35	--	[illegible]	--	84	--	96	--	99	--	--	--	--	--
37	V.U.V.	Sta 80	8	30	54	[illegible]	84	--	96	--	--	--	98	--	--	--	--
38	Large Basket 1/4" Mesh	Sta 100	--	11	--	33	--	57	--	84	--	99	--	--	--	--	--
39	Large Basket 1/4" Mesh	Sta 140	--	13	--	56	--	82	--	98	--	100	--	--	--	--	--
40	Large Basket 1/2" Mesh	Sta 120	--	26	--	62	--	80	--	98	--	99	--	--	--	--	--
41	Large Basket 1/2" Mesh	Sta 120	--	9	--	38	--	61	--	85	--	99	--	--	--	--	--
42	Large Basket 1/4" Mesh	Sta 120	--	24	--	60	--	79	--	93	--	99	--	--	--	--	--
43	Large Basket 1/4" Mesh	Sta 100	--	10	--	35	--	62	--	90	--	99	--	--	--	--	--
44	Large Basket 1/2" Mesh	Sta 120	--	39	--	92	--	99	--	--	--	--	--	--	--	--	--
45	Large Basket 1/2" Mesh	Sta 120	--	25	--	[illegible]	--	83	--	98	--	99	--	--	--	--	--
46	Large Basket 1/2" Mesh	Sta 120	--	28	--	55	--	76	--	96	--	99.5	--	--	--	--	--
47	Large Basket 1/4" Mesh	Sta 120	--	27	--	[illegible]	--	83	--	99	--	100	--	--	--	--	--
48	Excavated	Sta 10+00 U/S	--	5	10	23	34	--	71	--	--	--	97	--	--	--	--
49	Excavated	Sta 10+00 U/S	--	5	9	20	34	--	74	--	--	--	94	97	98	99	100
50	Excavated	Sta 8+00 U/S	--	2	4	14	31	--	64	--	--	--	76	82	86	92	98
51	Excavated	Sta 8+00 U/S	--	10	16	26	38	--	68	--	--	--	82	84	87	92	98
52	Excavated	Sta 6+00 U/S	24	35	46	59	67	--	79	--	--	--	87	93	96	97	98
53	Excavated	Sta 3+00 U/S	--	4	7	15	32	--	63				79	84	90	94	98
54	Excavated	Sta 1+00 D/S	13	20	27	46	63	--	79				88	93	95	97	100
55	Excavated	Sta 2+00 D/S	21	25	43	56	65	--	77				86	92	94	95	99
56	Excavated	Sta 13+00 D/S	9	20	29	41	49	--	68				81	88	93	96	99
57	Excavated	Sta 14+00 D/S	--	10	19	31	44	--	67	--	--	--	78	83	86	92	99

the sampled material which was retained by the various sieve sizes.

Specific gravity tests were run on some of the material obtained from bed-load samplers. The specific gravity for the material was 2.64 and 2.65 for the Elbow River and North Saskatchewan River respectively.

4.8 Hydrophone Observations

Hydrophone observations indicate that bed-load movement on the Elbow River begins when the flow is at about 900 c.f.s. On the North Saskatchewan River bed-load movement begins when the flow is at about 3,000 c.f.s.

The attempt to relate the level of sound to a quantitative measure of bed-load discharge failed. The reason for this failure was that sound, in addition to the sound of moving bed-load, was created by water turbulence around the hydrophone. The sound (acoustic energy) recorder was unable to distinquish between the sound of the moving bed-load and the water turbulence. Therefore the sound recorded was a combination of both water turbulence and bed-load movement. If all other sounds except the sounds of the bed-load movement could be filtered out, then perhaps some relation between level of sound and bed-load movement could be drawn.

4.9 Volumetric Pit Observations

The hydrographs of instantaneous discharge on the Elbow River at Bragg Creek for the days when bed-load movement occurred are shown on FIGURES 4-30, 4-31, 4-32 and 4-33. During the first three freshets (FIGURES 4-30, 4-31, 4-32) the bed-load movement was so small that it

could not be measured through the use of bed-load samplers. However, before and after each of these freshets the pit was surveyed and the amount of bed-load that moved into the pit was calculated.

The first, second and third flood deposited 120, 65, and 80 cubic yards of bed-load material into the pit respectively. For the last freshet (FIGURE 4-33) which was the major one, the pit filled up in 1 and 1/2 days and no survey measurements were taken.

4.10 Suspended Sediments

TABLE IV-5, IV-6 and IV-7 show the suspended sediment observations which were taken at Bragg Creek, Nordegg and Wilson's Bridge. The measured concentration (ppm) was taken at one station and was assumed to be the mean value for the whole section.

TABLE IV-5

SUSPENDED SEDIMENT MEASUREMENTS 1968 & 1969
ELBOW RIVER AT BRAGG CREEK

DATE	CONCENTRATION (ppm)	SUSPENDED LOAD (lb/min)	FLUID DISCHARGE (c.f.s.)
1968			
June 3	113	460	1,090
3	125	510	1,090
3	120	490	1,090
3	137	550	1,070
8	543	3,100	1,530
8	320	1,790	1,500
9	219	1,220	1,500
9	182	980	1,440
9	155	780	1,350
10	113	560	1,330
13	22	77	930
13	18	63	930
13	17	59	930
21	7	19	720
1969			
May 13	53	190	958
15	14	45	860
16	6	15	680
19	22	55	672
19	23	58	672
21	9	17	500
25	105	407	1,035
26	81	321	1,057
26	99	392	1,057
27	22	64	782
28	19	55	771
28	22	64	771
30	3	7	661
June 2	4	11	727
4	34	123	969
6	21	72	914
6	4	13	881
6	32	106	881
9	18	57	848
9	18	57	848
13	7	17	650
16	3	7	600
25	1,284	14,090	2,930
26	1,216	15,820	3,470

TABLE IV-5 cont.

DATE	CONCENTRATION (ppm)	SUSPENDED LOAD (lb/min)	FLUID DISCHARGE (c.f.s.)
1969			
June 27	779	7,250	2,490
27	703	5,840	2,220
28	773	6,300	2,180
30	742	9,530	3,430
July 2	501	4,520	2,410
3	325	2,690	2,210
4	209	1,660	2,130

TABLE IV-6

SUSPENDED SEDIMENT MEASUREMENTS - 1969
NORTH SASKATCHEWAN RIVER AT NORDEGG

DATE (1969)	CONCENTRATION (ppm)	SUSPENDED LOAD (lb/min)	FLUID DISCHARGE (c.f.s.)
July 10	209	9,296	11,880
10	200	8,896	11,880
12	245	9,906	10,800
12	183	7,399	10,800
13	113	3,625	8,570
13	118	3,786	8,570
14	123	3,431	7,450
14	129	3,598	7,450
15	100	2,434	6,500
15	98	2,385	6,500
15	115	2,799	6,500
29	200	6,971	9,310
29	181	6,309	9,310
31	99	2,954	7,970
August 7	145	4,408	8,120
7	171	5,199	8,120
12	138	4,201	8,130
12	122	3,714	8,130
14	71	1,640	6,170
14	60	1,386	6,170
14	79	1,825	6,170

TABLE IV-7

SUSPENDED SEDIMENT MEASUREMENTS - 1969
NORTH SASKATCHEWAN RIVER AT WILSON'S CROSSING

DATE (1969)		CONCENTRATION (ppm)	SUSPENDED LOAD (lb/min)	FLUID DISCHARGE (c.f.s.)
June	17	152	2,902	5,100
	17	214	4,086	5,100
	25	110	2,595	6,300
	25	117	2,760	6,300
	25	107	2,524	6,300
July	9	86	1,642	5,100
	9	112	2,138	5,100
	11	159	3,661	6,150
	11	156	3,592	6,150
	13	62	766	3,300
	13	56	692	3,300
	15	52	392	2,000
	15	84	629	2,000
	15	55	412	2,000
	29	92	1,516	4,400
	29	101	1,664	4,400
	31	192	3,307	4,600
	31	166	2,859	4,600
August	13	75	730	2,600
	13	78	759	2,600
	13	81	788	2,600

CHAPTER V

ANALYSIS OF DATA

5.1 Bed-Load Discharge Calculations from Bed-Load Sampling

TABLES IV-1 and IV-2 in Appendix A show all the bed-load samples that were taken at Nordegg and at Bragg Creek. From these samples the bed-load movement was determined.

TABLE V-1 shows an example of how the bed-load discharges were calculated. All calculations are based on 100% sampling efficiency and will be adjusted to their correct efficiency later on in this chapter.

Bed-load discharges at Nordegg and Bragg Creek were calculated in the manner shown on TABLE V-1. The results of these calculations are shown on TABLES V-2 and V-3. The results of calculations at Nordegg are plotted on FIGURES 5-1 and 5-2. The results tend to follow two different curves. One curve relates bed-load discharge to fluid discharge under normal conditions and the other curve relates bed-load discharge to fluid discharge when the river was readjusting to a channel shift. This shows that it is difficult to derive a accurate relation between fluid discharge and bed-load discharge, (FIGURES 5-1 and 5-2) for channel shifts, bed scour and moving bed-forms can readily change this relation. Other parameters such as mean velocity, water depth, charge and grain size will be used in a later section to try to produce graphical relationships which will not be affected by channel shifts, etc.

TABLE V-1

SAMPLE CALCULATIONS OF BED-LOAD DISCHARGE
ELBOW RIVER AT BRAGG CREEK

DATE	MEAN DISCHARGE (c.f.s.)	STATION	TOTAL WEIGHT OF SAMPLES (lbs)	NO. OF SAMPLES	TOTAL SAMPLING TIME (min.)	UNIT BED LOAD MOVEMENT (lbs/min.ft) $(4) \div \frac{(6)}{2}$	WIDTH	BED LOAD MOVEMENT (lbs/min) (7)x(8)
	3,000	40	--	-	--	--	-	--
JULY		50	658	4	13.25	24.83	10	248
1st		60	560	6	11.5	24.35	10	244
		70	1096	9	18.75	29.23	10	292
		80	595	6	16.5	18.03	10	180
		90	--	1	5	--	-	
								964
					TOTAL BED-LOAD MOVEMENT		= 964 lb/min	
	2,900	40	--	-	--	--	-	--
JULY		50	615	5	16	19.3	10	193
1st		60	1870	8	12.25	76.2	10	762
		70	1088	11	24.5	22.2	10	222
		80	366	4	8	22.9	10	229
		90	--	1	5	--	-	--
								1406
					TOTAL BED-LOAD MOVEMENT		= 1406 lb/min	

Note - Bed-load discharge was calculated assuming 100% bed-load sampler efficiency. These bed-load discharge rates will be adjusted later on in this section.

TABLE V-2

RESULTS OF BED-LOAD DISCHARGE CALCULATIONS
NORTH SASKATCHEWAN RIVER AT NORDEGG

DATE		NUMBER OF SAMPLES IN CALCULATIONS	TOTAL WIDTH OF MOVING STRIP (feet)	*CALCULATED BED-LOAD DISCHARGE (lb/min)	MEAN FLUID DISCHARGE (c.f.s.)	TYPE OF SAMPLER
June	24	22	140	495.9	10,358	¼" Mesh Basket
July	8	10	100	166.6	11,700	¼" Mesh Basket
	9	10	60	92.0	11,400	¼" Mesh Basket
	10	13	80	66.2	11,900	¼" Mesh Basket
	11	14	60	120.9	12,300	¼" Mesh Basket
	12	12	55	70.8	10,800	¼" Mesh Basket
	13	13	50	66.9	8,570	¼" Mesh Basket
	14	12	20	11.2	7,450	¼" Mesh Basket
	29	12	100	293.8	9,310	¼" Mesh Basket
	30	13	80	108.6	8,317	¼" Mesh Basket
August	7	16	110	189.7	8,120	¼" Mesh Basket
	8	6	100	313.0	9,166	¼" Mesh Basket
	12	15	100	135.4	8,150	¼" & ½" Mesh Basket
	13	12	85	89.9	6,800	¼" & ½" Mesh Basket
	14	8	80	100.4	6,169	¼" Mesh Basket

* Assuming bed-load sampler efficiency of 100%

TABLE V-3

RESULTS OF BED-LOAD DISCHARGE CALCULATIONS
ELBOW RIVER AT BRAGG CREEK, 1969

DATE	NUMBER OF SAMPLES IN CALCULATIONS	TOTAL WIDTH OF MOVING STRIP (feet)	*CALCULATED BED-LOAD DISCHARGE (lb/min)	MEAN FLUID DISCHARGE (c.f.s.)	TYPE OF SAMPLER
June 25	11	40	976	2,900	$\frac{1}{2}$'' Mesh Basket
June 26	11	30	902	3,200	$\frac{1}{2}$'' Mesh Basket
June 27	23	50	1,101	2,400	$\frac{1}{4}$'' Mesh Basket
	26	50	562	2,200	$\frac{1}{2}$'' Mesh Basket
June 28	32	50	747	2,250	$\frac{1}{4}$'' Mesh Basket
June 30	11	40	997	3,360	$\frac{1}{4}$'' Mesh Basket
June 30	26	50	1,558	3,180	$\frac{1}{4}$'' Mesh Basket
July 1	26	40	964	3,000	$\frac{1}{4}$'' Mesh Basket
July 1	29	40	1,406	2,900	$\frac{1}{4}$'' Mesh Basket
July 2	55	50	557	2,450	$\frac{1}{4}$'' Mesh Basket
July 3	28	50	469	2,200	$\frac{1}{4}$'' Mesh Basket
July 3	15	40	181	2,100	$\frac{1}{4}$'' Mesh Basket
July 4	27	50	225	2,100	$\frac{1}{4}$'' Mesh Basket
July 5	19	50	131	2,200	$\frac{1}{4}$'' Mesh Basket

* Assuming bed-load sampler efficiency of 100%

The results at Bragg Creek (shown on TABLE V-3) are plotted on FIGURE 5-3-A. The wide scatter is due to fluctuations in bed-load movement. These fluctuations are evident even when fluid discharge is relatively constant. An illustration of how bed-load discharge, calculated from bed-load samplers, fluctuates with time is shown on FIGURE 5-3-B. In an effort to even out the fluctions and obtain a correct average result, the bed-load discharge samples taken in 1967, 1968 and 1969 were grouped into large fluid discharge ranges. A mean fluid discharge for each discharge range was weighted according to the sampling time. TABLE V-4 shows how the weighted mean fluid discharges were obtained. Once the weighted mean fluid discharges were calculated, bed-load discharges were again calculated in the manner shown in TABLE V-5 and these results are summarized on TABLE V-6. These results were plotted on arithmetic and log-log paper and are shown on FIGURES 5-3 and 5-4 respectively. The arithmetic plot of FIGURE 5-3-C shows that by taking discharge ranges in which there are numerous bed-load samples, the scatter caused by fluctuations in bed-load movement can be reduced.

5.2 Analysis of Particle Size

TABLES IV-3 and IV-4 show the particle size distribution for the various types of samples taken at Bragg Creek and Nordegg respectively. FIGURE 5-5 is a plot showing the average size distribution for four stations at Bragg Creek where the samples were taken with the 1/4 inch mesh basket sampler. As the distances from the left bank increase, so do the particle sizes (see FIGURE 5-5). This increasing in size as distance progresses from the left bank, occurs only for a short distance.

TABLE V-4

CALCULATION OF MEAN DISCHARGES
ELBOW RIVER AT BRAGG CREEK

#	(1) DISCHARGE RANGE (c.f.s.)	(2) MEAN DISCHARGES SAMPLES WERE TAKEN AT (c.f.s.)	(3) TOTAL SAMPLING TIME	(4) COLUMN #2 x COLUMN #3	(5) MEAN DISCHARGE = TOTAL OF COL. #4 / TOTAL OF COL. #3
	1400	1,400	125	175×10^3	
		1,490	85	127×10^3	$\frac{1,165 \times 10^3}{752}$ =
1.		1,560	257	399×10^3	
	1900	1,630	285	464×10^3	
		TOTAL	752	$1,165 \times 10^3$	1,550 c.f.s.
	1900	1,900	60	114×10^3	
		2,000	151	302×10^3	
		2,100	94	197×10^3	
2.		2,100	203	426×10^3	$\frac{1,832 \times 10^3}{866}$ =
		2,200	95	209×10^3	
		2,200	155	341×10^3	
	2400	2,250	108	243×10^3	
		TOTAL	866	$1,832 \times 10^3$	2,120 c.f.s.
	2400	2,400			
3.			---	---	=
	2900	2,450			2,425 c.f.s.
	2900	2,900	60	174×10^3	
		2,900	37	107×10^3	
		3,000	62	186×10^3	$\frac{864 \times 10^3}{283}$ =
4.		3,180	62	197×10^3	
		3,200	48	153×10^3	
	3400	3,360	14	47×10^3	
		TOTAL	283	864×10^3	3,050 c.f.s.

TABLE V-5

SAMPLE CALCULATIONS OF BED-LOAD DISCHARGE
ELBOW RIVER AT BRAGG CREEK

DATE	DISCHARGE RANGE	STATION	TOTAL WEIGHT OF ALL SAMPLES (lbs)	TOTAL SAMPLING TIME (min)	BED-LOAD MOVEMENT (lb/min)
	1,900	40	--	--	--
		50	2,569	133.5	97.4
		60	4,659	218.5	106.8
	2,400	70	2,351	198.0	59.4
		80	1,573	161.0	48.9
		90	630	131.0	23.6
		100	--	--	336.1

TABLE V-6

SUMMARY OF RESULTS OF
BED-LOAD DISCHARGE CALCULATIONS

ELBOW RIVER AT BRAGG CREEK

MEAN DISCHARGE (c.f.s.)	DISCHARGE RANGE (c.f.s.)	TOTAL SAMPLING TIME (min)	BED-LOAD MOVEMENT BASED ON SAMPLER EFFICIENCY = 100% (lb/min)
1,550	1,400 1,900	752	142.4
2,120	1,900 2,400	866	336.1
2,425	2,400 2,900	285	651.3
3,050	2,900 3,360	283	1,091.0

and then the particle size remains constant. This is probably a result of some complex river sorting process.

FIGURE 5-6 shows the average grain size distribution at Stations 50 and 70 based on 6 excavated samples taken from the Volumetric Pit at Bragg Creek. From FIGURES 5-5 and 5-6 the following median diameters were taken to represent bed material size at Bragg Creek.

Station	Median Diameter
50	0.5 inches
60	1.00 inches
70	1.50 inches
80	1.5 inches
90	1.5 inches
100	1.5 inches
120	1.5 inches
130	1.5 inches

FIGURE 5-7 shows the grain size curves on the North Saskatchewan River at Nordegg for the following samples:

1. Average of all Excavated Samples.
2. Average of all 1/4 inch Mesh Basket Samples.
3. Average of all 1/2 inch Mesh Basket Samples.
4. Average of all V.U.V. Samples.

Whether or not a sorting process similar to that at Bragg Creek was occurring could not be determined at Nordegg. The reason being that there were an insufficient number of bed-load samples taken for size analysis at each station. Therefore an average median diameter (based on FIGURE 5-7) for bed-load discharge was taken to be about 0.75 inches.

5.3 Comparison of Size Distribution between Bed-Load Samplers

At Bragg Creek on the Elbow River most of the sampling was done with the 1/4 inch mesh basket. At Station 60, bed-load sampling was also done with the V.U.V. sampler. The grain size curves for the samples obtained with the 1/4 inch mesh basket and the V.U.V. are shown on FIGURE 5-8. There is only a small difference in size distribution and the mean diameters of both curves are practically the same.

On the North Saskatchewan River at Nordegg numerous samples were taken with the three different bed-load samplers. Most of these samples were taken at Station 120, because at this station there was always bed-load movement and the crane could easily be maneuvered into position. FIGURE 5-9 shows the average grain size curves for samples collected with the three samplers at Station 120. There is practically no differences in size between the different samples. FIGURE 5-10 shows the average grain size curves for the different samplers at Station 120 over a time period when there was little or no change in fluid discharge. The grain size curves in this figure are again similar.

FIGURES 5-8 through to 5-10 all tend to show that there is practically no differences in grain size distribution or actual grain size between the samples obtained with the different bed-load samplers. The very small differences that do occur are that the V.U.V. traps slightly more fines than the 1/2 inch or 1/4 inch mesh basket and the 1/4 inch mesh basket traps slightly more fines than the 1/2 inch mesh basket. Possible explanations for the lack of size differences between the samples obtained with different samplers are as follows:

(1) In the V.U.V. sampler, fines that first enter the sampler,

clog the screens and cause a change in the flow pattern. This change in flow pattern increases the turbulence within the sampler and causes the fine particles to go into suspension. These fines are then washed through the sampler and do not enter into the trapping section. This could cause a size distribution similar to that trapped by the 1/4 inch mesh basket.

(2) The 1/2 inch mesh basket sampler trapped slightly fewer fines than the 1/4 inch mesh basket sampler because the particles that are first caught in the 1/2 inch mesh sampler act as screens that trap smaller particles.

5.4 Comparison of Relative Sampling Efficiencies for Different Bed-Load Samplers

One or two stations at each site (Bragg Creek and Nordegg) were selected for calculating the different efficiencies between bed-load samplers.

At Nordegg, Station 120 was sampled extensively with the V.U.V., 1/2 inch and 1/4 inch mesh basket samplers. Relative efficiencies were calculated by taking the results of bed-load sampling at Station 120 for the dates July 31, August 7, 12, 13 and 14, 1969. The fluid discharge range during this sampling was from 6,000 - 8,000 c.f.s.; therefore because of the small fluid discharge range the bed-load discharge rate should be fairly constant and not affect the relative efficiencies. Since the bed-load rate would not vary enough over the above mentioned days, it was assumed that relative efficiencies would be fairly constant. The weight of the samples and the sampling time of each sampler taken at

Station 120 during the duration of the above days were added together and an average bed-load rate obtained (see TABLE V-7). The 1/4 inch mesh sampler was assumed to have 100% efficiency in order to compare the other samplers to it.

TABLE V-7

COMPARISON OF BED-LOAD SAMPLER EFFICIENCIES
NORTH SASKATCHEWAN RIVER AT NORDEGG, 1969

Discharge rate 6,000 - 8,000 c.f.s.
Station - 120
Dates on which samples were taken - July 31, August 7, 12, 13, 14

SAMPLER	TOTAL WEIGHT OF SAMPLES (lbs)	TOTAL SAMPLING TIME (min)	NUMBER OF SAMPLES	BED-LOAD DISCHARGE RATE	RELATIVE EFFICIENCIES
$\frac{1}{4}$" Mesh Basket	2,737	486	19	2.82	100
$\frac{1}{2}$" Mesh Basket	1,815	230	9	3.95	136
VUV	397	130	7	2.04	72.8

At Bragg Creek two different samplers were used at the same station on the same day. The results of this sampling is shown on TABLE V-8. The 1/4 inch mesh sampler is again assumed to have an efficiency of 100% for comparison purposes.

TABLE V-8

COMPARISON OF BED-LOAD SAMPLER EFFICIENCIES
ELBOW RIVER AT BRAGG CREEK

DATE	STATION (ft)	SAMPLER TYPE	TOTAL WEIGHT OF SAMPLES (lbs)	TOTAL SAMPLING TIME (min)	BED-LOAD DISCHARGE (lbs/min ft)	RELATIVE EFFICIENCIES	FLUID DISCHARGE (c.f.s.)
June 27	50	¼"	300	20	7.5	100	2,200
		VUV	115	14	5.12	68.2	
July 3	50	¼"	1,185	44	13.45	100	2,200
		VUV	245	25	6.54	48.6	
July 3	60	¼"	1,309	84	7.79	100	2,100
		VUV	106	15	4.71	60.5	
July 3	60	¼"	559	42	6.68	100	2,100
		VUV	361	35	6.88	103	

At Bragg Creek the efficiency of the V.U.V. sampler when compared to the 1/4 inch mesh basket has a range from 48.6% to 103%. (See TABLE V-8). The reason for this could be that the fluctuation of bed-load discharges have been such that a representative value of bed-load-discharge has not yet been obtained. In other words, there were not enough samples taken on each of the above days to average out the fluctuations and arrive at an accurate mean. Since there is only a small difference

in fluid discharge between the days shown on TABLE V-8, the hydraulic parameters should be approximately the same for each day and because of this the samples were added together for each station. The result is as shown on TABLE V-9.

TABLE V-9

COMPARISON OF BED-LOAD SAMPLER EFFICIENCIES
ELBOW RIVER AT BRAGG CREEK

(Samples taken on July 27 and July 3, 1969)

STATION	SAMPLER	TOTAL WEIGHT OF SAMPLES (lbs)	TOTAL SAMPLING TIME (min)	BED-LOAD DISCHARGE	RELATIVE EFFICIENCY	FLUID DISCHARGE
50	¼"	1,485	64	10.60	100	2,200
	VUV	360	39	6.15	53	2,200
60	¼"	1,868	126	7.42	100	2,100
	VUV	467	50	6.22	84	2,100

To arrive at one comparable efficiency for each sampler the results at Nordegg and Bragg Creek were averaged together. This may be incorrect since the comparable efficiencies may change with hydraulic and sediment parameters. Therefore, the relative efficiencies given below will be taken to mean that over a large discharge range the relative efficiencies average out to be as follows:

1/4 inch mesh basket	100%	(assume for comparison sake)
1/2 inch mesh basket	136%	
V.U.V.	70%	

A possible explanation for the high efficiency of the 1/2 inch mesh basket could be that the larger mesh offers less resistance to flow and thereby has a better efficiency than the 1/4 inch mesh basket.

The V.U.V. is less efficient because the fine particles which enter the sampler clog the screens and prevent water bearing sediment from entering into the sampler.

5.5 Volumetric Pit Analysis at Bragg Creek

The volumetric pit was described in section 3.5 and 4.9. FIGURES 4-30, 4-32 and 4-33 show the 1969 instantaneous hydrographs of flows above competent conditions which deposited 120, 65 and 80 cubic yards of material into the pit respectively. In 1968, two freshets occurred in which the flows were above competent conditions (Hollingshead 1968). The freshets had a maximum instantaneous discharge of 1,600 c.f.s. and 1,300 c.f.s. and filled the pit with 550 and 172 cubic yards of bed-load material respectively.

Based on the assumption that the pit was 100% efficient at trapping all the bed-load discharge, a bed-load discharge vs fluid discharge curve was constructed by trial and error from the data obtained in 1968 and 1969. FIGURES 5-3 and 5-4 show this curve on an arithmetic plot and log-log plot respectively. Since this curve was constructed from fluid discharge data up to 1,600 c.f.s., it is only accurate up to that point.

No results were obtained from the main freshet of 1969 because the pit could not be measured at high flows.

5.6 Actual Efficiencies of Samplers

FIGURES 5-3 and 5-4 show the bed-load discharge at Bragg Creek (obtained by assuming that the 1/4 inch mesh basket was 100% efficient) and the actual bed-load discharge (obtained from volumetric pit calculations). From these figures the apparent efficiency of the 1/4 inch mesh basket was determined for fluid discharges up to 1,600 c.f.s. and is shown in TABLE V-10.

TABLE V-10

1/4" MESH BASKET SAMPLER EFFICIENCY 1969

FLUID DISCHARGE (c.f.s.)	EFFICIENCY (%)	MULTIPLICATION FACTOR
1,200	0	∞
1,400	35	2.9
1,600	45	2.2

NOTE: Multiplication factor is the factor by which the measured bed-load discharge is multiplied by to obtain the actual bed-load discharge.

Hollingshead for the 1968 study, used an efficiency of 32% when the fluid discharge was 1,400 c.f.s. This compares well with the efficiency of 35% shown in TABLE V-10 for the same fluid discharge. The actual bed-load movement above 1,600 c.f.s. is unknown. If the actual bed-load discharge curve of FIGURE 5-3 was extended for higher discharges

it would cross the measured bed-load discharge curve. This would mean that the 1/4 inch mesh sampler would have to have an efficiency of greater than 100% at high fluid discharge. No data is available to prove or disprove it, and until it is actually known how the bed-load discharge varies with high fluid discharges an overall efficiency will have to be used. The overall efficiency of 45% was applied to the 1/4 inch mesh basket samples based on the obtained efficiency of 45% when the fluid discharge was 1,600 c.f.s. at Bragg Creek and on the efficiency of 45% reported by Hubbel, 1964. FIGURE 5-3 shows the actual bed-load discharge at Bragg Creek obtained from the volumetric pit and from the 1/4 inch mesh basket samples using an efficiency of 45%.

FIGURE 5-1 shows the actual bed-load movement at Nordegg obtained from applying an efficiency of 45% to the 1/4 inch mesh basket.

If the actual efficiency of 1/4 inch mesh basket is 45% then from the previous section on relative efficiencies, the actual efficiencies of the other samplers are approximately as follows:

Sampler	Relative Efficiency	Actual Efficiency
1/4 inch mesh basket	100%	45%
1/2 inch mesh basket	136%	60%
V.U.V.	70%	30%

5.7 Analysis of Suspended Sediment

TABLES IV-3, IV-4 and IV-5 show the results of suspended sediment measurements taken at Bragg Creek, Nordegg and Wilson's Bridge respectively. FIGURES 5-11, 5-12 and 5-13 show the relationship between suspended sediment and fluid discharge for the Elbow River at Bragg Creek and at Nordegg and Wilson's Bridge on the North Saskatchewan River.

The relation between suspended sediment discharge and bed-load discharge for Bragg Creek and Nordegg is shown on TABLES V-11 and V-12 respectively.

For the Elbow River at Bragg Creek the bed-load discharge was an average of 18% of the suspended load for fluid discharges above competent conditions. At Nordegg the suspended sediment in the river could have been higher than normal because of increased wash load due to clearing operations upstream on the Big Horn Damsite. The average ratio of bed-load is suspended load for flows above competent conditions was about 12%.

The sediment yield was calculated at Bragg Creek, Nordegg and Wilson's Bridge using the relation between suspended sediment discharge versus fluid discharge and flow duration curves. Sediment yield results are as follows:

Location	Sediment Yield Tons/Square Mile/Year
Elbow River at Bragg Creek	180
North Saskatchewan River at Wilson's Bridge	217
North Saskatchewan River at Nordegg	213

5.8 Effect of Channel Shift at Nordegg

The channel shift occurred over a period from June 30 to July 10, 1969. The effect of the channel shift was that the bed-load discharge diminished appreciably as can be seen on FIGURE 5-2 curve #1. FIGURE

TABLE V-11

RELATION BETWEEN SUSPENDED SEDIMENT DISCHARGE AND BED-LOAD DISCHARGE

ON

NORTH SASKATCHEWAN RIVER AT NORDEGG

FLUID DISCHARGE (c.f.s.)	(u) SUSPENDED SEDIMENT (lb/min)	(w) BED-LOAD DISCHARGE (lb/min)	w/u (%)
4,000	530	29	5.5
5,000	980	67	6.8
6,000	1,600	130	8.1
7,000	2,500	235	9.4
8,000	3,500	385	11.0
9,000	4,900	600	12.2
10,000	6,600	900	13.6
11,000	8,500	1,250	14.7
12,000	10,800	1,700	15.7
13,000	13,200	2,250	17.0

TABLE V-12

RELATION BETWEEN SUSPENDED SEDIMENT DISCHARGE AND BED-LOAD DISCHARGE

FOR

ELBOW RIVER AT BRAGG CREEK

FLUID DISCHARGE (c.f.s.)	(u) SUSPENDED SEDIMENT (lb/min)	(w) BED-LOAD DISCHARGE (lb/min)	w/u
800	35	0	--
900	100	20	20.0
1,000	250	50	20.0
1,100	520	105	20.3
1,200	780	140	18.0
1,300	1,050	170	16.2
1,400	1,350	210	15.6
1,500	1,700	250	14.7
1,600	2,050	320	15.6
1,700	2,500	400	16.0
1,800	3,000	500	16.6
1,900	3,500	600	17.2
2,000	4,000	700	17.5
2,100	4,600	840	18.2
2,200	5,200	1,000	19.2
2,300	6,000	1,150	19.2
2,400	6,600	1,340	20.3
2,500	7,400	1,600	21.6
2,600	8,200	1,800	21.9
2,700	9,200	2,100	22.8
2,800	10,000	2,400	24.0

5-2 also shows that during the channel shift, when the fluid discharge varied there was little change in bed-load discharge. Another effect of the channel shift was that the moving strip of bed-load discharge became narrower and shifted towards the left bank.

FIGURE 4-14 shows the channel cross-section adjacent to the Nordegg Bridge on various dates. The July 8th cross-sections were taken at the time of the channel shift. At this time, there was a low fluid discharge, the river bed had scoured down more than at any other time. It would appear that, the scour was a result of the normal bed-load discharge being deposited somewhere upstream and the river downstream trying to regain its bed-load discharge by scouring the bed.

5.9 Comparison of Sampling Procedures from a Cableway and from a Road Bridge

Generally, sampling from the cableway at Bragg Creek was twice as fast as with a crane equipped truck at Nordegg Bridge. Using the cableway, the average time required to raise a basket sampler, weight it, remove sample and return the sampler to the river bottom is about two minutes. A V.U.V. sampler takes about four minutes.

In comparison, it seems that the crane equipped truck is inefficient, however, the Nordegg Bridge is at least twice as high as the Bragg Creek cableway from the water surface and it is necessary to maneuver the samplers through the Nordegg Bridge columns. The advantages of the crane equipped truck were the ease of operation, the portability of the machine, its large capacity and the fact that the technicians could be doing other jobs while the sampler was in the water.

5.10 Calculations of Bed-Shear Stress at Bragg Creek

FIGURES 4-19 through to 4-27 show the velocity profile on semi-log paper for depths within 1 foot of the bed. The velocity profile can be represented by a non-dimensional velocity equation:

$$\frac{V}{V_*} = A \log \frac{y}{k_s} + B$$

Where V is the velocity at a distance y from the bed, k_s is Nikuradse's sand grain diameter and A and B are constants. The usual value of A equal to 5.75 was used to calculate V_*. The value of k_s and B need not be known when calculating V_*. Once V_* is calculated bed-shear stress (τo) is equal to γV_*^2. Bed-shear was calculated for fluid discharges equal to 880, 1,090 and 3,290 c.f.s. TABLE V-13 shows the results of the calculations. FIGURES 4-16, 4-17 and 4-18 show the bed-shear stress distribution for the different discharges.

Comparisons of average bed-shear stress calculated from the formula $\tau o = \gamma RS$ and the formula $\frac{V}{V_*} = A \log \frac{y}{k_s} + B$ are shown on TABLE V-14.

5.11 Statistical Analysis of Bed-Load Samples at Bragg Creek

For each bed-load sample taken at Bragg Creek in 1969 a bed-load discharge was calculated using the efficiencies described in section 5.1. These bed-load rates were then divided according to discharge ranges and the stations at which the samples were taken. TABLE V-15 in Appendix A shows the results. The bed-load discharges were then analyzed for their mean and standard deviation. TABLE V-16 shows the result. Note how the V.U.V. sampler always has a lower standard deviation then the basket

TABLE V-13

CALCULATIONS OF BED-SHEAR STRESS FROM VELOCITY PROFILES OF FIGURES 4-20 THROUGH TO 4-28

FLUID DISCHARGE	STATION	SHEAR VELOCITY V_* (ft/sec)	(τ_o) BED-SHEAR STRESS (lb/ft^2) = $V_*^2\rho$
880	50	.5304	0.490
	60	.41217	0.330
	70	.661	0.848
	80	.696	0.940
	90	.673	0.879
	100	.348	0.239
	110	.619	0.744
	120	.303	0.176
	130	.063	0.007
	AVERAGE	.478	0.517
1,090	50	.678	0.891
	60	.696	0.940
	70	.504	0.492
	80	.548	0.583
	90	.603	0.705
	100	.456	0.404
	110	.649	0.816
	120	.44	0.376
	130	.40	0.311
	AVERAGE	0.553	0.613
3,290	50	1.183	2,300
	60	.939	1.710
	70	.814	1.284
	80	.713	.986
	90	.609	.884
	100	.809	1,270
	110	.675	.885
	120	1.030	2.060
	130	.704	.961
	AVERAGE	0.831	1.371

TABLE V-14

COMPARISON OF BED-SHEAR STRESS AS CALCULATED BY TWO DIFFERENT METHODS

ELBOW RIVER AT BRAGG CREEK

FLUID DISCHARGE	AVERAGE BED-SHEAR STRESS FROM VELOCITY PROFILE (TABLE V-14) (lb/ft^2)	AVERAGE BED-SHEAR FROM $\tau_o = \gamma RS$ (lb/ft^2)
880	.517	= 0.669
1,090	.613	= 0.855
3,290	1.371	= 1.520

NOTE - These average bed-shear stresses refer to the whole cross-section.

TABLE V-16

THE MEAN AND STANDARD DEVIATION OF BED-LOAD SAMPLES TAKEN AT BRAGG CREEK

DISCHARGE RANGE (cfs)	STATION (ft)	SAMPLER	MEAN (lb/min ft)	STANDARD DEVIATION (lb/min ft)	NUMBER OF SAMPLES
2050-2400	50	V.U.V.	20.8	6.8	10
	50	1/4" Mesh Basket	21.5	9.8	25
	60	V.U.V.	23.4	15.9	17
		1/4" Mesh Basket	32.5	37.4	50
	70	1/4" Mesh Basket	32.8	55.4	35
	80	1/4" Mesh Basket	30.2	36.0	28
2400-2750	60	1/4" Mesh Basket	20.2	29.3	11
2750-3100	50	1/4" Mesh Basket	32.5	25.5	7
	60	1/4" Mesh Basket	65.3	53.2	16
	70	1/4" Mesh Basket	51.7	50.6	23
2750-3100	80	1/4" Mesh Basket	46.2	52.4	10
3100-3500	50	1/4" Mesh Basket	71.3	33.3	13
		1/2" Mesh Basket	13.7	16.5	6
	60	1/4" Mesh Basket	98.8	78.7	7
	70	1/4" Mesh Basket	61.0	80.9	8
	80	1/4" Mesh Basket	28.5	36.0	9

samplers. This should mean that when using basket and V.U.V. bed-load samplers, the V.U.V. should require fewer samples in order to obtain a representative mean.

5.12 Cooper-Peterson Analysis

The work done by Cooper and Peterson (1968) was described in section 2.3. For this analysis the curves developed by Cooper-Peterson relating $V_m^2/(G_s - 1)gh$, h/D_{50} and C were used. Note that C (concentration) used in these curves, represents the concentration of sediment due to bed material discharge. In order to determine bed material discharge from the sampled streams, suspended sediment and bed material must be analyzed for size. No size analysis was done on the 1969 suspended sediment samples, therefore the results of size analysis done in 1968 study (Hollingshead 1968) must be used. These results (size analysis, Elbow River at Bragg Creek 1968) show that at a fluid discharge of 1,500 c.f.s., the suspended sediment load was 90% wash load and 10% bed material load. Knowing the suspended sediment discharge and the bed-load discharge the bed material discharge can now be determined. Therefore at a fluid discharge of 1,500 c.f.s. in the Elbow River at Bragg Creek, the bed-load discharge constitutes 60% of the bed material discharge. At higher fluid discharges more of the bed material will be in suspension and therefore the ratio between bed-load discharge and bed material discharge will be lower. Because of the lack of particle size information on suspended sediment samples taken in 1969, bed material load for all fluid discharges could not be calculated. Therefore bed-load discharges were used to determine C when calculating points on Cooper-Peterson curves.

TABLE V-17 and V-18 in Appendix A show the data obtained from samples taken at Bragg Creek and Nordegg respectively that were plotted on FIGURE 5-14. The samples that were taken on one day at one station were averaged together to give a more accurate mean value of bed-load discharge. Concentrations for each station were calculated from unit bed-load discharge divided by unit fluid discharge. The mean velocity, depth and mean diameter are also given on TABLES V-17 and V-18.

The field samples were grouped together into ranges of h/D_{50} and an average h/D_{50} obtained for each range as shown on the legend of FIGURE 5-14. For each average h/D_{50} a line was interpolated from Cooper-Peterson curves and plotted on FIGURE 5-14. Therefore, the plotted points represent field data for each average h/D_{50} and the lines represent curves interpolated from Cooper-Peterson's analysis for each average h/D_{50}.

The plot of FIGURE 5-14 shows that there is good correlation between Cooper-Peterson curves and field data, when h/D_{50} is from 10 to 90. Beyond h/D_{50} value of 90 the curves give higher bed-material transport rates then measured bed-load discharge. The reason for this could be one or any combination of the following:

(1) As h/D_{50} increases the amount of bed material that goes into suspension increases and causes the ratio between bed-load discharge and bed material discharge to decrease.

(2) Not a large enough supply of bed-load material to meet hydraulic conditions.

(3) Incorrect sampler efficiencies.

(4) Non-uniform sampling measurements.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the observations of Chapter IV and the results of Chapter V the following conclusions have been drawn.

(1) The bed-load movement at fluid discharges between 800 c.f.s. and 1,500 c.f.s. in the Elbow River at Bragg Creek is known from the results of the 1968 and 1969 volumetric pit.

(2) The efficiency of the 1/4 inch mesh basket sampler on the Elbow River at Bragg Creek is shown below for the various fluid discharges:

Efficiency	Discharge (c.f.s.)
0%	1,200
35%	1,400
45%	1,600

For fluid discharges above 1,600 c.f.s. the actual bed-load discharge is unknown. In order to estimate bed-load discharge at higher fluid discharges, an efficiency of 45% for the 1/4 inch mesh basket was assumed.

(3) The comparable average efficiencies of the three bed-load samplers are as follows:

Sampler	Efficiency
1/4 inch mesh basket	45%
1/2 inch mesh basket	60%
V.U.V.	30%

These are approximate and may only apply to the two sites studied and over a very limited range of flows.

(4) A large number of bed-load samples are required for quantitative analysis because of the large time-wise fluctuations of transport rates.

(5) There is practically no difference in particle size distribution between bed-load samples taken with the 1/2 inch mesh basket, the 1/4 inch mesh basket and the V.U.V. sampler, when the fluid discharge is constant and the samples are taken from the same station.

(6) There is a variation of the median bed-load particle size at Bragg Creek across the section on which sampling was carried out.

(7) Bed-load movement begins on the Elbow River at Bragg Creek at about 800 c.f.s. and bed-load measurements with samplers can begin at about 1,300 c.f.s. Therefore, there are about 10 days a year on the average when sampling can take place.

(8) Bed-load movement begins on the North Saskatchewan River at Nordegg at about 3,000 c.f.s. and measurements with bed-load samplers can begin at around 5,000 c.f.s. Therefore, there are about 90 days a year on the average when sampling can take place.

(9) Channel shifts, like the one that occurred upstream from Nordegg Bridge on the North Saskatchewan River have a large effect on the movement of bed-load.

(10) The ratio of bed-load discharge to suspended sediment discharge for flows above competent conditions average about 12% at Nordegg and 19% at Bragg Creek.

(11) The sediment yield at Bragg Creek on the Elbow River, at Nordegg on

the North Saskatchewan River, and at Wilson's Bridge on the North Saskatchewan River is 180, 212 and 217 tons per square mile per year respectively.

(12) The time required between the end of a bed-load sample and the start of a new sample is roughly 2 minutes when using a cablecar and 4 minutes when sampling from a bridge with a truck operated crane. These times are for basket samplers and should be doubled when using the V.U.V. sampler.

(13) Comparison of measured bed-load discharge with estimates of bed material discharge taken from curves of Cooper-Peterson (1968) shows that there is a reasonable agreement when h/D_{50} is from 10 to 90. Above the h/D_{50} value of 90 the bed-load charge estimated from the curves is larger than results obtained by bed-load samplers.

6.2 Recommendations

(1) Some method of surveying a large volumetric pit is required when flows are high. This is required so that actual bed-load rates at high fluid discharge can be compared with that obtained with bed-load samplers. One possible method would be the use of six or more cableways strung across the pit.

(2) Since the truck used has a crane capacity of roughly a ton, bed-load samplers should be made larger, so that the combined weight of sample collected plus sampler would be about 1500 lbs. This sampler would produce a more confident mean, because the longer sampling time would average out more of the fluctuations in bed-load movement.

(3) Sampling should continue at one station over periods of days, so

that a record of bed-load discharge fluctuations can be obtained. Once these are obtained, these results should be analyzed statistically so that some confidence limit can be placed on our mean value of bed-load discharge. Statistical analysis of results would also show how many samplers are required to produce accurate results.

(4) Bed-load sampling in a gravel river where channel shifts may occur, produce questionable results. Therefore, if at all possible, future locations should be in areas where the channels cannot shift.

(5) In order to correlate the level of sound created by bed-load movement to a quantitative measure of bed-load discharge, a hydrophone should be designed so that all unwanted sounds can be filtered out.

LIST OF REFERENCES

Cooper, R. H. and Peterson, A.W., 1968 - "Analysis of Comprehensive Bed-Load Transport Data from Flumes", A.S.C.E. Hydraulics Specialty Conference M.I.T.

Hollingshead, A. B., 1968 - "Measurements of the Bed-Load Discharge of the Elbow River", M.Sc. Thesis, University of Alberta.

Hollingshead, A. B., 1968 - "Sediment Transport Measurements Elbow River at Bragg Creek", Internal Report, Research Council of Alberta.

Hubbel, D. W., 1964 - "Apparatus and Techniques for Measuring Bed-Load", Geological Survey, Water Supply Paper 1748, U.S. Government Printing Office.

Jarocki, Walenty - "Correlation between the Quantity of Bed-Load and Suspended Load in Rivers", Archiwum Hydrotechniki, Poland, Vol. 14, No. 5, pp 535-570, 1967. English Translation published by U.S.D.C. TT-66-57039.

Shteynman, B. S., 1966 - "Certain Patterns in the Movement of Streambed Sediments", Soviet Hydrology, American Geophysical Union, Washington, pp 650-653.

DEFINITIONS

The following definitions were used:

Bed-Load	Bed material that is transported by rolling, sliding or skipping along the bed.
Bed-Load Discharge	The quantity of bed-load by dry weight passing a given cross-section per unit of time.
Bed Material	The alluvial material that makes up the stream bed.
Bed Material Discharge	The quantity of bed material passing a given cross section per unit of time, and composed of bed-load plus bed material transported as suspended load.
Competent Conditions	Hydraulic conditions corresponding to the first displacement of bed material.
Freshet	A small flood of short duration.
Sampling Efficiency	Used with bed-load samplers and defined as the ratio of weight of bed-load collected during a given sampling time to the weight of bed-load that would have passed through the sampler mouth area if the sampler was not present.
Sediment (Fluvial (Sediment)	Fragmentary material that originates from the weathering of rocks and is transported by, suspended in, or deposited from, water.
Suspended Sediment	That part of the sediment discharge that is in suspension.

Wash Load — That part of the sediment load that consists of fine grains which have washed off the drainage basin and are finer than the stream bed.

SYMBOLS

The following symbols were used:

Symbol	Meaning	Dimensions
b	Channel breadth	L
C	Bed-load charge	
D	Particle diameter or equivalent diameter	L
D_X	The specific size at which X percent of the total sample weight is smaller than	L
G_s	Specific Gravity of sediment	
g	Gravitational acceleration	L/T^2
h	Depth of flow	L
k_s	Equivalent sand-grain roughness	L
s	Slope, general	
V	Velocity, general	L/T
V_m	Mean velocity	L/T
V_e	Shear velocity	L/T
y	Distance from bed	L
f	Mass density of fluid	FT^2/L^4
s	Mass density of solids	FT^2/L^4
	Shear stress	F/L^2

ABBREVIATIONS

The following abbreviations were used:

c.f.s.	cubic feet per second
D/S	Downstream
Fig.	Figure
f.p.s.	Feet per second
ft.	Foot
lb.	Pound
min.	Minute
Sta.	Station
U/S	Upstream
vs	Versus
%	Percent

APPENDIX A

TABLES IV-1
IV-2
V-15
V-17
V-18

TABLE IV-1

ELBOW RIVER AT BRAGG CREEK

BED LOAD SAMPLES

(1) SAMPLE I.D. NUMBER	(2) DATE	(3) STATION (FT.)	(4) SAMPLER TYPE	(5) SAMPLE TIME (MIN.)	(6) SAMPLE WEIGHT (LBS.)	(7) DEPTH (FT.)	(8) MEAN VELOCITY (FPS)	(9) DISCHARGE (CFS)	(10) SAMPLE ANALYSIS NUMBER	(11) MEAN DIAMETER FROM ANALYSIS (INCHES)
9001	25 6 69	50	1/4" MESH BASKET	5.00	20.0	2.7	6.42	2970		
9002	25 6 69	50	1/4" MESH BASKET	2.00	30.0	2.7	6.42	2890	105	0.63
9003	25 6 69	50	1/2" MESH BASKET	5.00	228.0	2.7	6.42	2845	107	0.55
9101	25 6 69	60	1/4" MESH BASKET	5.00	240.0	2.7	9.00	2970		
9102	25 6 69	60	1/4" MESH BASKET	2.00	22.0	2.7	9.00	2910	106	1.50
9103	25 6 69	60	1/2" MESH BASKET	5.00	34.0	2.7	9.00	2845	108	1.65
9201	25 6 69	70	1/4" MESH BASKET	3.00	300.0	2.6	9.58	2990		
9202	25 6 69	70	1/4" MESH BASKET	1.50	5.0	2.6	9.58	2910		
9203	25 6 69	70	1/2" MESH BASKET	5.00	14.0	2.6	9.58	2845	109	1.70
9301	25 6 69	80	1/4" MESH BASKET	0.75	142.0	3.3	10.32	2890		
9302	25 6 69	80	1/2" MESH BASKET	3.00	285.0	3.3	10.32	2845		
9401	26 6 69	50	1/2" MESH BASKET	5.00	40.0	3.5	6.98	3250		
9402	26 6 69	50	1/2" MESH BASKET	10.00	232.0	3.5	6.98	3250		
9403	26 6 69	50	1/2" MESH BASKET	5.00	265.0	3.5	6.98	3282		
9404	26 6 69	50	1/2" MESH BASKET	4.00	1.0	3.5	6.98	3186		
9405	26 6 69	50	1/2" MESH BASKET	5.00	4.0	3.5	6.98	3186		
9406	26 6 69	50	1/2" MESH BASKET	8.00	110.0	3.5	6.98	3186		
9501	26 6 69	70	1/2" MESH BASKET	3.00	250.0	3.5	9.54	3186		
9502	26 6 69	70	1/2" MESH BASKET	2.00	4.0	3.5	9.54	3186		
9503	26 6 69	70	1/2" MESH BASKET	3.00	315.0	3.5	9.54	3186		
9504	26 6 69	70	1/2" MESH BASKET	2.00	325.0	3.5	9.54	3186		
9505	26 6 69	70	1/2" MESH BASKET	1.25	240.0	3.5	9.54	3186		
9601	27 6 69	60	1/4" MESH BASKET	4.00	260.0	2.6	7.73	2485		
9701	27 6 69	50	1/4" MESH BASKET	5.00	115.0	2.5	5.35	2455	110	0.26
9702	27 6 69	50	1/4" MESH BASKET	5.00	75.0	2.5	5.35	2395		
9703	27 6 69	50	1/4" MESH BASKET	6.00	100.0	2.5	5.35	2395		
9704	27 6 69	50	1/4" MESH BASKET	4.00	10.0	2.5	5.35	2261		
9705	27 6 69	50	V. U. V.	5.00	40.0	2.5	5.35	2095		
9706	27 6 69	50	V. U. V.	4.00	45.0	2.5	5.35	2095		
9707	27 6 69	50	V. U. V.	5.00	30.0	2.5	5.35	2095		
9801	27 6 69	60	1/4" MESH BASKET	3.00	310.0	2.6	7.73	2380		
9802	27 6 69	60	1/4" MESH BASKET	2.00	275.0	2.6	7.73	2365		
9803	27 6 69	60	1/4" MESH BASKET	1.00	65.0	2.6	7.73	2350		
9804	27 6 69	60	1/4" MESH BASKET	1.00	115.0	2.6	7.73	2350		
9805	27 6 69	60	1/2" MESH BASKET	5.00	35.0	2.6	7.73	2247		
9806	27 6 69	60	1/2" MESH BASKET	10.00	130.0	2.6	7.73	2233		
9807	27 6 69	60	1/2" MESH BASKET	10.00	350.0	2.6	7.73	2233		
9808	27 6 69	60	V. U. V.	5.00	100.0	2.6	7.73	2095	113	1.00
9809	27 6 69	60	V. U. V.	4.00	100.0	2.6	7.73	2095		
9810	27 6 69	60	V. U. V.	4.00	20.0	2.6	7.73	2095		
9901	27 6 69	70	1/4" MESH BASKET	1.00	40.0	2.9	8.43	2350		
9902	27 6 69	70	1/4" MESH BASKET	0.50	115.0	2.9	8.43	2350		
9903	27 6 69	70	1/4" MESH BASKET	1.00	10.0	2.9	8.43	2350		
9904	27 6 69	70	1/4" MESH BASKET	2.00	70.0	2.9	8.43	2335		
9905	27 6 69	70	1/2" MESH BASKET	5.00	10.0	2.9	8.43	2233		
9906	27 6 69	70	1/2" MESH BASKET	5.00	275.0	2.9	8.43	2233		
9907	27 6 69	70	1/2" MESH BASKET	2.00	100.0	2.9	8.43	2219		
9908	27 6 69	70	1/2" MESH BASKET	3.00	290.0	2.9	8.43	2219		
9909	27 6 69	70	V. U. V.	5.00	75.0	2.9	8.43	2095		
9910	27 6 69	70	V. U. V.	4.00	125.0	2.9	8.43	2095		

TABLE IV-1 PAGE 2

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
9911	27 6 69	70	V. U. V.	4.00	4.0	2.9	8.43	2095		
10001	27 6 69	80	1/4" MESH BASKET	1.00	130.0	2.8	9.27	2335		
10002	27 6 69	80	1/4" MESH BASKET	1.00	2.0	2.8	9.27	2335		
10003	27 6 69	80	1/4" MESH BASKET	2.00	145.0	2.8	9.27	2335		
10004	27 6 69	80	1/4" MESH BASKET	2.00	30.0	2.8	9.27	2335		
10005	27 6 69	80	1/2" MESH BASKET	2.50	220.0	2.8	9.27	2219		
10006	27 6 69	80	1/2" MESH BASKET	1.50	80.0	2.8	9.27	2205		
10007	27 6 69	80	1/2" MESH BASKET	2.00	5.0	2.8	9.27	2191		
10008	27 6 69	80	1/2" MESH BASKET	3.00	100.0	2.8	9.27	2191		
10009	27 6 69	80	1/2" MESH BASKET	4.00	60.0	2.8	9.27	2163	112	1.70
10010	27 6 69	80	V. U. V.	4.00	15.0	2.8	9.27	2205		
10101	27 6 69	90	1/4" MESH BASKET	1.00	1.0	3.5	7.38	2335		
10102	27 6 69	90	1/4" MESH BASKET	2.00	1.0	3.5	7.38	2335		
10103	27 6 69	90	1/4" MESH BASKET	2.00	35.0	3.5	7.38	2335		
10104	27 6 69	90	1/4" MESH BASKET	3.00	10.0	3.5	7.38	2305		
10105	27 6 69	90	1/2" MESH BASKET	2.00	0.0	3.5	7.38	2191		
10106	27 6 69	90	1/2" MESH BASKET	5.00	0.0	3.5	7.33	2171		
10107	27 6 69	90	1/2" MESH BASKET	1.00	2.0	3.5	7.38	2171		
10108	27 6 69	90	1/2" MESH BASKET	5.00	40.0	3.5	7.33	2163		
10109	27 6 69	90	1/2" MESH BASKET	5.00	0.0	3.5	7.38	2121		
10110	27 6 69	90	1/2" MESH BASKET	5.00	0.0	3.5	7.33	2121		
10201	27 6 69	100	1/4" MESH BASKET	4.00	10.0	4.3	7.51	2305		
10202	27 6 69	100	1/2" MESH BASKET	5.00	0.5	4.3	7.51	2135		
10203	27 6 69	100	1/2" MESH BASKET	5.00	0.0	4.3	7.51	2135		
10301	27 6 69	110	1/4" MESH BASKET	1.50	0.0	4.2	7.81	2305		
10302	27 6 69	110	1/2" MESH BASKET	5.00	0.0	4.2	7.81	2149		
10303	27 6 69	110	1/2" MESH BASKET	3.50	2.0	4.2	7.81	2135		
10401	27 6 69	65	1/4" MESH BASKET	3.00	45.0	2.6	7.92	2305	111	2.00
10501	27 6 69	40	1/4" MESH BASKET	8.00	1.0	1.4	3.18	2275		
10601	27 6 69	55	1/4" MESH BASKET	5.00	70.0	2.8	6.35	2261		
10602	27 6 69	55	1/2" MESH BASKET	10.00	75.0	2.8	6.35	2247		
10701	28 6 69	50	1/4" MESH BASKET	5.00	120.0	2.7	5.16	2219		
10702	28 6 69	50	1/4" MESH BASKET	5.00	115.0	2.7	5.16	2219		
10703	28 6 69	50	1/4" MESH BASKET	5.00	40.0	2.7	5.16	2219		
10704	28 6 69	50	1/4" MESH BASKET	5.00	40.0	2.7	5.16	2219		
10705	28 6 69	50	1/4" MESH BASKET	5.00	55.0	2.7	5.16	2233		
10706	28 6 69	50	1/4" MESH BASKET	5.00	45.0	2.7	5.16	2380		
10707	28 6 69	50	1/4" MESH BASKET	5.00	10.0	2.7	5.16	2410		
10801	28 6 69	60	1/4" MESH BASKET	3.00	180.0	2.4	7.73	2219		
10802	28 6 69	60	1/4" MESH BASKET	3.00	260.0	2.4	7.73	2219		
10803	28 6 69	60	1/4" MESH BASKET	2.00	10.0	2.4	7.73	2219		
10804	28 6 69	60	1/4" MESH BASKET	5.00	300.0	2.4	7.73	2191	115	1.20
10805	28 6 69	60	1/4" MESH BASKET	3.00	55.0	2.4	7.73	2247		
10806	28 6 69	60	1/4" MESH BASKET	4.00	165.0	2.4	7.73	2261		
10807	28 6 69	60	1/4" MESH BASKET	4.00	25.0	2.4	7.73	2261		
10808	28 6 69	60	1/4" MESH BASKET	4.00	300.0	2.4	7.73	2455		
10901	28 6 69	70	1/4" MESH BASKET	4.00	70.0	2.3	7.77	2219		
10902	28 6 69	70	1/4" MESH BASKET	4.00	70.0	2.3	7.77	2219		
10903	28 6 69	70	1/4" MESH BASKET	1.00	15.0	2.3	7.77	2219		
10904	28 6 69	70	1/4" MESH BASKET	1.00	20.0	2.3	7.77	2205		

TABLE IV-I PAGE 3

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
10905	28 6 69	70	1/4" MESH BASKET	3.00	95.0	2.3	7.77	2275		
10906	28 6 69	70	1/4" MESH BASKET	3.00	70.0	2.3	7.77	2305		
10907	28 6 69	70	1/4" MESH BASKET	4.00	300.0	2.3	7.77	2335		
11001	28 6 69	80	1/4" MESH BASKET	4.00	60.0	2.6	8.11	2205	114	2.10
11002	28 6 69	80	1/4" MESH BASKET	4.00	290.0	2.6	8.11	2205		
11003	28 6 69	80	1/4" MESH BASKET	4.00	55.0	2.6	8.11	2205		
11101	28 6 69	90	1/4" MESH BASKET	5.00	185.0	3.2	7.96	2205		
11102	28 6 69	90	1/4" MESH BASKET	5.00	20.0	3.2	7.96	2205		
11103	28 6 69	90	1/4" MESH BASKET	3.00	100.0	3.2	7.96	2205		
11201	28 6 69	100	1/4" MESH BASKET	5.00	2.0	4.1	7.60	2205		
11202	28 6 69	100	1/4" MESH BASKET	5.00	0.0	4.1	7.60	2191		
11301	28 6 69	110	1/4" MESH BASKET	5.00	0.0	4.7	7.39	2191		
11401	28 6 69	45	1/4" MESH BASKET	10.00	0.0	2.2	4.20	2205		
11501	30 6 69	40	1/4" MESH BASKET	4.00	0.0	2.4	5.00	3370		
11601	30 6 69	50	1/4" MESH BASKET	3.00	330.0	4.5	9.12	3370		
11602	30 6 69	50	1/4" MESH BASKET	1.00	10.0	4.5	9.12	3410		
11603	30 6 69	50	1/4" MESH BASKET	2.00	100.0	4.5	9.12	3390		
11604	30 6 69	50	1/4" MESH BASKET	4.00	150.0	4.5	9.12	3180		
11605	30 6 69	50	1/4" MESH BASKET	4.00	260.0	4.5	9.12	3180		
11606	30 6 69	50	1/4" MESH BASKET	4.00	290.0	4.5	9.12	3180		
11607	30 6 69	50	1/4" MESH BASKET	3.00	280.0	4.5	9.12	3180		
11608	30 6 69	50	1/4" MESH BASKET	2.00	190.0	4.5	9.12	3180		
11609	30 6 69	50	1/4" MESH BASKET	3.00	300.0	4.5	9.12	3180	118	1.30
11701	30 6 69	60	1/4" MESH BASKET	1.00	60.0	3.3	9.57	3390		
11702	30 6 69	60	1/4" MESH BASKET	1.00	175.0	3.3	9.57	3370		
11703	30 6 69	60	1/4" MESH BASKET	1.00	20.0	3.3	9.57	3370		
11704	30 6 69	60	1/4" MESH BASKET	1.25	110.0	3.3	9.57	3180		
11705	30 6 69	60	1/4" MESH BASKET	1.25	250.0	3.3	9.57	3180		
11706	30 6 69	60	1/4" MESH BASKET	1.00	40.0	3.3	9.57	3180		
11707	30 6 69	60	1/4" MESH BASKET	1.00	40.0	3.3	9.57	3180		
11801	30 6 69	80	1/4" MESH BASKET	1.00	5.0	3.5	10.90	3350		
11802	30 6 69	80	1/4" MESH BASKET	1.00	10.0	3.5	10.90	3350		
11803	30 6 69	80	1/4" MESH BASKET	1.25	25.0	3.5	10.90	3180		
11804	30 6 69	80	1/4" MESH BASKET	3.00	180.0	3.5	10.90	3180	117	2.00
11805	30 6 69	80	1/4" MESH BASKET	2.50	2.0	3.5	10.90	3180		
11806	30 6 69	80	1/4" MESH BASKET	3.00	50.0	3.5	10.90	3180		
11807	30 6 69	80	1/4" MESH BASKET	3.00	295.0	3.5	10.90	3180		
11808	30 6 69	80	1/4" MESH BASKET	2.00	8.0	3.5	10.90	3180		
11809	30 6 69	80	1/4" MESH BASKET	3.00	50.0	3.5	10.90	3180		
11901	30 6 69	70	1/4" MESH BASKET	1.00	0.0	3.9	9.50	3330		
11902	30 6 69	70	1/4" MESH BASKET	2.00	100.0	3.9	9.50	3330	116	2.00
11903	30 6 69	70	1/4" MESH BASKET	1.00	20.0	3.9	9.50	3180		
11904	30 6 69	70	1/4" MESH BASKET	1.25	20.0	3.9	9.50	3180		
11905	30 6 69	70	1/4" MESH BASKET	2.00	310.0	3.9	9.50	3180		
11906	30 6 69	70	1/4" MESH BASKET	1.25	230.0	3.9	9.50	3180		
11907	30 6 69	70	1/4" MESH BASKET	1.00	1.0	3.9	9.50	3180		
11908	30 6 69	70	1/4" MESH BASKET	1.50	20.0	3.9	9.50	3180		
12001	30 6 69	90	1/4" MESH BASKET	5.00	20.0	3.4	8.56	3180		
12002	30 6 69	90	1/4" MESH BASKET	9.00	15.0	3.4	8.56	3180		
12101	30 6 69	100	1/4" MESH BASKET	5.00	0.0	4.9	7.00	3180		

TABLE IV-I PAGE 4

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
12201	1 7 69	50	1/4" MESH BASKET	3.25	133.0	4.1	8.75	3165		
12202	1 7 69	50	1/4" MESH BASKET	4.00	175.0	4.1	8.75	3144		
12203	1 7 69	50	1/4" MESH BASKET	3.00	120.0	4.1	8.75	3123		
12204	1 7 69	50	1/4" MESH BASKET	3.00	230.0	4.1	8.75	3102		
12301	1 7 69	60	1/4" MESH BASKET	2.50	35.0	3.2	9.59	3081		
12302	1 7 69	60	1/4" MESH BASKET	3.00	125.0	3.2	9.59	3081		
12303	1 7 69	60	1/4" MESH BASKET	1.00	125.0	3.2	9.59	3060		
12304	1 7 69	60	1/4" MESH BASKET	1.00	115.0	3.2	9.59	3039		
12305	1 7 69	60	1/4" MESH BASKET	2.00	85.0	3.2	9.59	3039		
12306	1 7 69	60	1/4" MESH BASKET	2.00	75.0	3.2	9.59	3018		
12401	1 7 69	70	1/4" MESH BASKET	2.00	1.0	3.8	9.28	3018		
12402	1 7 69	70	1/4" MESH BASKET	4.00	150.0	3.8	9.28	2997		
12403	1 7 69	70	1/4" MESH BASKET	1.00	5.0	3.8	9.28	2997		
12404	1 7 69	70	1/4" MESH BASKET	4.00	270.0	3.8	9.28	2997		
12405	1 7 69	70	1/4" MESH BASKET	2.00	155.0	3.8	9.28	2997		
12406	1 7 69	70	1/4" MESH BASKET	2.00	95.0	3.8	9.28	3018		
12407	1 7 69	70	1/4" MESH BASKET	2.00	280.0	3.8	9.28	3018		
12408	1 7 69	70	1/4" MESH BASKET	0.25	15.0	3.8	9.28	3018		
12409	1 7 69	70	1/4" MESH BASKET	1.50	125.0	3.8	9.28	2997	119	3.00
12501	1 7 69	80	1/4" MESH BASKET	2.00	0.0	3.4	10.50	2997		
12502	1 7 69	80	1/4" MESH BASKET	2.00	10.0	3.4	10.50	2876		
12503	1 7 69	80	1/4" MESH BASKET	3.50	165.0	3.4	10.50	2876		
12504	1 7 69	80	1/4" MESH BASKET	3.00	150.0	3.4	10.50	2997		
12505	1 7 69	80	1/4" MESH BASKET	3.00	90.0	3.4	10.50	2997		
12506	1 7 69	80	1/4" MESH BASKET	3.00	180.0	3.4	10.50	2997		
12601	1 7 69	90	1/4" MESH BASKET	5.00	0.0	3.5	8.46	2997		
12701	1 7 69	40	1/4" MESH BASKET	5.00	0.0	2.2	3.98	2997		
12801	1 7 69	50	1/4" MESH BASKET	4.00	230.0	3.0	6.72	2997		
12802	1 7 69	50	1/4" MESH BASKET	3.00	45.0	3.0	6.72	2997		
12803	1 7 69	50	1/4" MESH BASKET	3.00	135.0	3.0	6.72	2997		
12804	1 7 69	50	1/4" MESH BASKET	3.00	170.0	3.0	6.72	2997		
12805	1 7 69	50	1/4" MESH BASKET	3.00	35.0	3.0	6.72	2876		
12901	1 7 69	60	1/4" MESH BASKET	2.00	235.0	3.4	7.23	2876		
12902	1 7 69	60	1/4" MESH BASKET	1.50	45.0	3.4	7.23	2855		
12903	1 7 69	60	1/4" MESH BASKET	1.50	230.0	3.4	7.23	2855		
12904	1 7 69	60	1/4" MESH BASKET	1.25	6.0	3.4	7.23	2834		
12905	1 7 69	60	1/4" MESH BASKET	1.50	145.0	3.4	7.23	2834		
12906	1 7 69	60	1/4" MESH BASKET	1.50	110.0	3.4	7.23	2813		
12907	1 7 69	60	1/4" MESH BASKET	1.50	10.0	3.4	7.23	2892		
12908	1 7 69	60	1/4" MESH BASKET	1.50	170.0	3.4	7.23	2871		
13001	1 7 69	70	1/4" MESH BASKET	1.50	1.0	3.9	7.76	2871		
13002	1 7 69	70	1/4" MESH BASKET	2.00	4.0	3.9	7.76	2850		
13003	1 7 69	70	1/4" MESH BASKET	2.00	3.0	3.9	7.76	2829		
13004	1 7 69	70	1/4" MESH BASKET	3.00	2.0	3.9	7.76	2808		
13005	1 7 69	70	1/4" MESH BASKET	5.00	325.0	3.9	7.76	2787		
13006	1 7 69	70	1/4" MESH BASKET	2.00	200.0	3.9	7.76	2787		
13007	1 7 69	70	1/4" MESH BASKET	1.50	2.0	3.9	7.76	2757		
13008	1 7 69	70	1/4" MESH BASKET	2.50	125.0	3.9	7.76	2787		
13009	1 7 69	70	1/4" MESH BASKET	2.50	290.0	3.9	7.76	2787		
13010	1 7 69	70	1/4" MESH BASKET	1.25	130.0	3.9	7.76	2797		

TABLE IV-I PAGE 6

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
13602	2 7 69	90	1/4" MESH BASKET	4.00	12.0	3.6	6.21	2493		
13603	2 7 69	90	1/4" MESH BASKET	5.00	100.0	3.6	6.21	2493		
13604	2 7 69	90	1/4" MESH BASKET	5.50	20.0	3.6	6.21	2430		
13605	2 7 69	90	1/4" MESH BASKET	7.00	35.0	3.6	6.21	2410		
13606	2 7 69	90	1/4" MESH BASKET	10.00	105.0	3.6	6.21	2410		
13607	2 7 69	90	1/4" MESH BASKET	8.00	140.0	3.6	6.21	2410		
13608	2 7 69	90	1/4" MESH BASKET	10.00	235.0	3.6	6.21	2390		
13701	2 7 69	100	1/4" MESH BASKET	4.00	0.0	3.9	6.82	2493		
13702	2 7 69	100	1/4" MESH BASKET	10.00	0.0	3.9	6.82	2410		
13301	2 7 69	95	1/4" MESH BASKET	10.00	10.0	3.9	6.43	2410		
13901	3 7 69	50	1/4" MESH BASKET	10.00	285.0	2.6	5.96	2270		
13902	3 7 69	50	1/4" MESH BASKET	4.00	130.0	2.6	5.96	2270		
13903	3 7 69	50	1/4" MESH BASKET	4.00	105.0	2.6	5.96	2270		
13904	3 7 69	50	1/4" MESH BASKET	4.25	55.0	2.6	5.96	2270		
13905	3 7 69	50	1/4" MESH BASKET	4.00	100.0	2.6	5.96	2270		
13906	3 7 69	50	1/4" MESH BASKET	6.25	215.0	2.6	5.96	2270	124	0.28
13914	3 7 69	50	1/4" MESH BASKET	5.00	105.0	2.6	5.96	2100		
13915	3 7 69	50	1/4" MESH BASKET	6.00	180.0	2.6	5.96	2100	128	0.35
13907	3 7 69	50	V. U. V.	2.00	25.0	2.6	5.96	2100		
13908	3 7 69	50	V. U. V.	3.00	20.0	2.6	5.96	2100		
13909	3 7 69	50	V. U. V.	5.00	55.0	2.6	5.96	2100		
13910	3 7 69	50	V. U. V.	4.00	40.0	2.6	5.96	2100		
13911	3 7 69	50	V. U. V.	3.00	40.0	2.6	5.96	2100		
13912	3 7 69	50	V. U. V.	2.50	10.0	2.6	5.96	2100		
13913	3 7 69	50	V. U. V.	5.00	55.0	2.6	5.96	2100	127	0.14
14001	3 7 69	60	1/4" MESH BASKET	3.00	135.0	2.8	6.73	2250		
14002	3 7 69	60	1/4" MESH BASKET	3.00	65.0	2.8	6.73	2250		
14003	3 7 69	60	1/4" MESH BASKET	3.25	60.0	2.8	6.73	2250		
14004	3 7 69	60	1/4" MESH BASKET	4.25	1.0	2.8	6.73	2250		
14005	3 7 69	60	1/4" MESH BASKET	3.00	120.0	2.8	6.73	2230		
14006	3 7 69	60	1/4" MESH BASKET	3.00	105.0	2.8	6.73	2230		
14007	3 7 69	60	1/4" MESH BASKET	3.50	7.0	2.8	6.73	2230		
14008	3 7 69	60	1/4" MESH BASKET	3.25	1.0	2.8	6.73	2230		
14009	3 7 69	60	1/4" MESH BASKET	3.00	30.0	2.8	6.73	2209		
14010	3 7 69	60	1/4" MESH BASKET	3.50	140.0	2.8	6.73	2209		
14011	3 7 69	60	1/4" MESH BASKET	3.00	180.0	2.8	6.73	2209		
14012	3 7 69	60	1/4" MESH BASKET	4.00	35.0	2.8	6.73	2188	125	1.25
14016	3 7 69	60	1/4" MESH BASKET	5.00	2.0	2.8	6.73	2100		
14017	3 7 69	60	1/4" MESH BASKET	10.00	14.0	2.8	6.73	2100		
14018	3 7 69	60	1/4" MESH BASKET	15.00	44.0	2.8	6.73	2100		
14019	3 7 69	60	1/4" MESH BASKET	5.00	180.0	2.8	6.73	2100		
14020	3 7 69	60	1/4" MESH BASKET	4.00	10.0	2.8	6.73	2100		
14021	3 7 69	60	1/4" MESH BASKET	5.00	180.0	2.8	6.73	2100		
14013	3 7 69	60	V. U. V.	5.00	36.0	2.8	6.73	2100		
14014	3 7 69	60	V. U. V.	5.00	20.0	2.8	6.73	2100		
14015	3 7 69	60	V. U. V.	5.00	50.0	2.8	6.73	2100		
14101	3 7 69	70	1/4" MESH BASKET	3.00	5.0	2.7	7.07	2167		
14102	3 7 69	70	1/4" MESH BASKET	5.00	85.0	2.7	7.07	2167		
14103	3 7 69	70	1/4" MESH BASKET	5.00	19.0	2.7	7.07	2167		
14104	3 7 69	70	1/4" MESH BASKET	10.00	194.0	2.7	7.07	2146		

TABLE IV-1 PAGE 7

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
14105	3 7 69	70	1/4" MESH BASKET	3.50	1.0	2.7	7.07	2100		
14106	3 7 69	70	1/4" MESH BASKET	5.50	1.0	2.7	7.07	2100		
14107	3 7 69	70	1/4" MESH BASKET	5.00	1.0	2.7	7.07	2100		
14108	3 7 69	70	1/4" MESH BASKET	10.00	1.0	2.7	7.07	2100		
14201	3 7 69	80	1/4" MESH BASKET	5.00	42.0	2.9	6.95	2146		
14202	3 7 69	90	1/4" MESH BASKET	10.00	48.0	2.9	6.95	2146		
14203	3 7 69	80	1/4" MESH BASKET	10.00	84.0	2.9	6.95	2125		
14204	3 7 69	80	1/4" MESH BASKET	10.00	110.0	2.9	6.95	2125	126	1.60
14205	3 7 69	80	1/4" MESH BASKET	5.00	1.0	2.9	6.95	2100		
14206	3 7 69	80	1/4" MESH BASKET	10.00	1.0	2.9	6.95	2100		
14301	3 7 69	90	1/4" MESH BASKET	10.00	2.0	3.0	6.84	2125		
14302	3 7 69	90	1/4" MESH BASKET	15.00	2.0	3.0	6.84	2083		
14303	3 7 69	90	1/4" MESH BASKET	12.00	1.0	3.0	6.84	2100		
14401	4 7 69	50	1/4" MESH BASKET	5.00	70.0	2.6	5.91	2100		
14402	4 7 69	50	1/4" MESH BASKET	5.00	140.0	2.6	5.91	2100	129	0.31
14501	4 7 69	70	1/4" MESH BASKET	15.00	260.0	2.5	7.42	2100		
14502	4 7 69	70	1/4" MESH BASKET	10.00	80.0	2.5	7.42	2100		
14503	4 7 69	70	1/4" MESH BASKET	10.00	1.0	2.5	7.42	2100		
14504	4 7 69	70	1/4" MESH BASKET	10.00	50.0	2.5	7.42	2100		
14505	4 7 69	70	1/4" MESH BASKET	6.00	2.0	2.5	7.42	2100		
14506	4 7 69	70	1/4" MESH BASKET	10.00	60.0	2.5	7.42	2100		
14507	4 7 69	70	1/4" MESH BASKET	10.00	115.0	2.5	7.42	2100	130	1.25
14601	4 7 69	80	1/4" MESH BASKET	10.00	1.0	2.7	7.08	2100		
14602	4 7 69	80	1/4" MESH BASKET	15.00	2.0	2.7	7.08	2100		
14603	4 7 69	80	1/4" MESH BASKET	11.00	15.0	2.7	7.08	2100		
14604	4 7 69	80	1/4" MESH BASKET	10.00	15.0	2.7	7.08	2100		
14701	4 7 69	90	1/4" MESH BASKET	15.00	40.0	2.7	7.46	2100		
14702	4 7 69	90	1/4" MESH BASKET	10.00	7.0	2.7	7.46	2100		
14703	4 7 69	90	1/4" MESH BASKET	10.00	20.0	2.7	7.46	2100		
14801	4 7 69	100	1/4" MESH BASKET	10.00	0.5	3.2	6.69	2100		
14901	4 7 69	60	1/4" MESH BASKET	5.00	310.0	2.4	6.93	2100		
14902	4 7 69	60	1/4" MESH BASKET	3.50	60.0	2.4	6.93	2100		
14903	4 7 69	60	1/4" MESH BASKET	3.50	55.0	2.4	6.93	2100		
14904	4 7 69	60	1/4" MESH BASKET	3.50	3.0	2.4	6.93	2100		
14905	4 7 69	60	1/4" MESH BASKET	3.50	30.0	2.4	6.93	2100		
14906	4 7 69	60	1/4" MESH BASKET	3.50	3.0	2.4	6.93	2100		
14907	4 7 69	60	1/4" MESH BASKET	4.00	25.0	2.4	6.93	2100		
14908	4 7 69	60	1/4" MESH BASKET	3.50	3.0	2.4	6.93	2100		
14909	4 7 69	60	1/4" MESH BASKET	3.50	25.0	2.4	6.93	2100		
14910	4 7 69	60	1/4" MESH BASKET	8.00	45.0	2.4	6.93	2100	131	1.10
14911	4 7 69	60	V. U. V.	3.50	50.0	2.4	6.93	2100		
14912	4 7 69	60	V. U. V.	3.50	15.0	2.4	6.93	2100		
14913	4 7 69	60	V. U. V.	4.00	45.0	2.4	6.93	2100		
14914	4 7 69	60	V. U. V.	3.50	35.0	2.4	6.93	2100		
14915	4 7 69	60	V. U. V.	3.50	15.0	2.4	6.93	2100		
14916	4 7 69	60	V. U. V.	3.50	55.0	2.4	6.93	2100		
14917	4 7 69	60	V. U. V.	3.00	40.0	2.4	6.93	2100		
14918	4 7 69	60	V. U. V.	3.00	1.0	2.4	6.93	2100		
14919	4 7 69	60	V. U. V.	3.50	80.0	2.4	6.93	2100		
14920	4 7 69	60	V. U. V.	3.50	25.0	2.4	6.93	2100	132	1.35

TABLE IV-1 PAGE 8

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
15001	5 7 69	50	1/4" MESH BASKET	5.00	50.0	2.5	5.60	2083		
15002	5 7 69	50	1/4" MESH BASKET	6.00	185.0	2.5	5.60	2083		
15003	5 7 69	50	1/4" MESH BASKET	5.00	110.0	2.5	5.60	2083		
15004	5 7 69	50	1/4" MESH BASKET	5.00	90.0	2.5	5.60	2083		
15005	5 7 69	50	1/4" MESH BASKET	5.00	92.0	2.5	5.60	2083		
15006	5 7 69	50	1/4" MESH BASKET	5.00	65.0	2.5	5.60	2083		
15101	5 7 69	60	1/4" MESH BASKET	3.00	3.0	2.3	6.50	2083		
15102	5 7 69	60	1/4" MESH BASKET	4.00	55.0	2.3	6.50	2083		
15103	5 7 69	60	1/4" MESH BASKET	3.00	1.0	2.3	6.50	2083		
15104	5 7 69	60	1/4" MESH BASKET	4.00	10.0	2.3	6.50	2083		
15105	5 7 69	60	1/4" MESH BASKET	6.00	10.0	2.3	6.50	2083		
15106	5 7 69	60	1/4" MESH BASKET	10.00	1.0	2.3	6.50	2083		
15201	5 7 69	70	1/4" MESH BASKET	15.00	40.0	2.4	7.00	2062		
15202	5 7 69	70	1/4" MESH BASKET	20.00	18.0	2.4	7.00	2020		
15301	5 7 69	80	1/4" MESH BASKET	15.00	10.0	2.6	6.73	1980		
15302	5 7 69	80	1/4" MESH BASKET	15.00	50.0	2.6	6.73	1980	133	2.20
15401	5 7 69	90	1/4" MESH BASKET	10.00	5.0	2.6	7.03	1960		
15402	5 7 69	90	1/4" MESH BASKET	15.00	15.0	2.6	7.03	1960		
15501	5 7 69	100	1/4" MESH BASKET	15.00	1.0	3.1	6.34	1960		

TABLE IV-2

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

BED LOAD SAMPLES

(1) SAMPLE I.D. NUMBER	(2) DATE	(3) STATION (FT.)	(4) SAMPLER TYPE	(5) SAMPLE TIME (MIN.)	(6) SAMPLE WEIGHT (LBS.)	(7) DEPTH (FT.)	(8) MEAN VELOCITY (FPS)	(9) DISCHARGE (CFS)	(10) SAMPLE ANALYSIS NUMBER	(11) MEAN DIAMETER FROM ANALYSIS (INCHES)
101	24 6 69	46	1/4" MESH BASKET	10.00	0.0	3.6	3.16	10358		1.00
201	24 6 69	56	1/4" MESH BASKET	10.00	0.0	5.5	5.91	10358		1.00
301	24 6 69	62	1/4" MESH BASKET	10.00	70.0	6.7	7.09	10358	1	1.00
302	24 6 69	62	1/4" MESH BASKET	10.00	1.0	6.7	7.09	10358	1	1.00
303	24 6 69	62	1/4" MESH BASKET	10.00	130.0	6.7	7.09	10358	1	1.00
304	24 6 69	62	1/4" MESH BASKET	10.00	10.0	6.7	7.09	10358	1	1.00
305	24 6 69	62	1/4" MESH BASKET	10.00	40.0	6.7	7.09	10358	1	1.00
401	24 6 69	80	1/4" MESH BASKET	5.00	0.0	6.3	6.65	10358		1.00
402	24 6 69	80	1/4" MESH BASKET	11.00	0.0	6.3	6.65	10358		1.00
403	24 6 69	80	1/4" MESH BASKET	15.00	0.0	6.3	6.55	10358		1.00
501	24 6 69	100	1/4" MESH BASKET	5.00	1.0	5.1	6.78	10358	2	0.85
502	24 6 69	100	1/4" MESH BASKET	12.00	22.0	5.1	6.78	10358	2	0.85
503	24 6 69	100	1/4" MESH BASKET	20.00	80.0	5.1	6.78	10358	2	0.85
601	24 6 69	120	1/4" MESH BASKET	10.00	240.0	5.6	7.60	10358	3	1.25
602	24 6 69	120	1/4" MESH BASKET	10.00	210.0	5.6	7.60	10358		1.25
701	24 6 69	140	1/4" MESH BASKET	10.00	150.0	6.6	6.44	10358		1.25
702	24 6 69	140	1/4" MESH BASKET	10.00	190.0	6.6	6.44	10358	4	1.00
801	24 6 69	160	1/4" MESH BASKET	10.00	70.0	7.9	7.18	10358		1.00
802	24 6 69	160	1/4" MESH BASKET	10.00	15.0	7.9	7.18	10358		1.00
901	24 6 69	180	1/4" MESH BASKET	15.00	1.0	8.7	4.24	10358		1.00
902	24 6 69	180	1/4" MESH BASKET	15.00	1.0	3.9	5.74	10358		1.00
1001	24 6 69	255	1/4" MESH BASKET	10.00	0.0	3.9	5.74	10358		1.00
1101	8 7 69	60	1/4" MESH BASKET	10.00	0.0	5.8	6.25	10700		
1102	8 7 69	60	1/4" MESH BASKET	10.00	0.0	5.8	6.25	10700		
1201	8 7 69	80	1/4" MESH BASKET	10.00	175.0	7.2	8.12	10700	5	1.20
1202	8 7 69	80	1/4" MESH BASKET	10.00	135.0	7.2	8.12	10700		1.20
1203	8 7 69	80	1/4" MESH BASKET	10.00	160.0	7.2	8.12	10700		1.20
1301	8 7 69	100	1/4" MESH BASKET	10.00	1.0	7.6	7.28	10700		
1302	8 7 69	100	1/4" MESH BASKET	15.00	10.0	7.6	7.28	10700		
1401	8 7 69	120	1/4" MESH BASKET	25.00	10.0	8.3	7.95	10700		
1501	8 7 69	140	1/4" MESH BASKET	25.00	2.0	7.6	6.76	10700		
1601	8 7 69	160	1/4" MESH BASKET	25.00	1.0	8.4	6.87	10700		
1701	9 7 69	60	1/4" MESH BASKET	20.00	0.0	6.3	5.93	11400		
1801	9 7 69	80	1/4" MESH BASKET	10.00	35.0	8.0	8.05	11400		
1802	9 7 69	80	1/4" MESH BASKET	30.00	145.0	8.0	8.05	11400	6	0.85
1803	9 7 69	80	1/4" MESH BASKET	10.00	10.0	8.0	8.05	11400		
1804	9 7 69	80	1/4" MESH BASKET	10.00	15.0	8.0	8.05	11400		
1805	9 7 69	80	1/4" MESH BASKET	15.00	124.0	8.0	8.05	11400		
1901	9 7 69	100	1/4" MESH BASKET	30.00	35.0	7.9	7.49	11400		
2001	9 7 69	120	1/4" MESH BASKET	30.00	110.0	8.6	7.86	11400		
2101	9 7 69	140	1/4" MESH BASKET	30.00	0.0	7.7	7.22	11400		
2201	9 7 69	160	1/4" MESH BASKET	50.00	0.0	8.7	6.89	11400		
2301	9 7 69	65	V. U. V.	10.00	35.0	6.0	5.85	11400		
2302	9 7 69	65	V. U. V.	10.00	35.0	6.0	5.85	11400	7	0.80
2303	9 7 69	65	V. U. V.	10.00	15.0	6.0	5.85	11400		
2401	10 7 69	60	1/4" MESH BASKET	20.00	0.0	6.2	6.36	11900		
2501	10 7 69	80	1/4" MESH BASKET	30.00	5590	8.3	7.75	11900		
2502	10 7 69	80	1/4" MESH BASKET	30.00	55.0	8.3	7.75	11900		
2503	10 7 69	80	1/4" MESH BASKET	20.00	5.0	8.3	7.75	11900		
2504	10 7 69	80	1/4" MESH BASKET	30.00	55.0	8.3	7.75	11900	9	1.10

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
2505	10 7 69	80	1/4" MESH BASKET	30.00	65.0	8.3	7.75	11900		
2601	10 7 69	100	1/4" MESH BASKET	30.00	50.0	8.3	7.85	11900		
2602	10 7 69	100	1/4" MESH BASKET	30.00	25.0	8.3	7.85	11900	8	1.25
2603	10 7 69	100	1/4" MESH BASKET	40.00	65.0	8.3	7.85	11900		
2701	10 7 69	120	1/4" MESH BASKET	60.00	270.0	9.5	8.08	11900		
2702	10 7 69	120	1/4" MESH BASKET	20.00	10.0	9.5	8.08	11900		
2801	10 7 69	140	1/4" MESH BASKET	30.00	1.0	8.1	7.20	11900		
2901	10 7 69	175	1/4" MESH BASKET	30.00	0.0	10.1	5.66	11900		
22701	11 7 69	60	1/4" MESH BASKET	20.00	0.0	6.4	5.96	12300		
22801	11 7 69	80	1/4" MESH BASKET	30.00	100.0	9.0	7.68	12300		
22802	11 7 69	80	1/4" MESH BASKET	30.00	35.0	9.0	7.68	12300		
22803	11 7 69	80	1/4" MESH BASKET	30.00	75.0	9.0	7.68	12300	10	1.15
22808	11 7 69	80	1/4" MESH BASKET	30.00	210.0	9.0	7.68	12300		
22809	11 7 69	80	1/4" MESH BASKET	15.00	20.0	9.0	7.68	12300		
22810	11 7 69	80	1/4" MESH BASKET	20.00	15.0	9.0	7.68	12300		
22804	11 7 69	80	V. U. V.	20.00	35.0	9.0	7.68	12300		
22805	11 7 69	80	V. U. V.	20.00	40.0	9.0	7.68	12300		
22806	11 7 69	80	V. U. V.	20.00	25.0	9.0	7.68	12300		
22807	11 7 69	80	V. U. V.	30.00	30.0	9.0	7.68	12300	11	1.35
22901	11 7 69	100	1/4" MESH BASKET	30.00	250.0	8.3	7.41	12300		
3001	11 7 69	120	1/4" MESH BASKET	30.00	25.0	9.2	7.60	12300		
3101	11 7 69	140	1/4" MESH BASKET	30.00	0.0	8.1	7.47	12300		
3201	12 7 69	80	1/4" MESH BASKET	30.00	60.0	8.2	7.41	10800	12	0.75
3202	12 7 69	80	1/4" MESH BASKET	30.00	20.0	8.2	7.41	10800		
3203	12 7 69	80	1/4" MESH BASKET	30.00	85.0	8.2	7.41	10800		
3204	12 7 69	80	1/4" MESH BASKET	30.00	20.0	8.2	7.41	10800		
3301	12 7 69	100	1/4" MESH BASKET	40.00	95.0	8.3	7.37	10800	13	0.90
3401	12 7 69	130	1/4" MESH BASKET	30.00	0.0	8.6	7.61	10800		
3402	12 7 69	130	1/4" MESH BASKET	30.00	1.0	8.6	7.61	10800		
3501	12 7 69	120	1/4" MESH BASKET	30.00	80.0	8.1	7.29	10800		
3502	12 7 69	120	1/4" MESH BASKET	30.00	110.0	8.1	7.29	10800		
3601	12 7 69	150	1/4" MESH BASKET	30.00	0.0	7.6	7.28	10800		
3701	12 7 69	300	1/4" MESH BASKET	30.00	5.0	4.6	4.86	10800		
3801	12 7 69	360	1/4" MESH BASKET	30.00	0.0	9.4	5.65	10800		
3901	13 7 69	80	1/4" MESH BASKET	30.00	55.0	7.5	7.07	8570		
3902	13 7 69	80	1/4" MESH BASKET	30.00	90.0	7.5	7.07	8570		
3903	13 7 69	80	1/4" MESH BASKET	30.00	135.0	7.5	7.07	8570	14	0.52
3904	13 7 69	80	1/4" MESH BASKET	30.00	115.0	7.5	7.07	8570		
4001	13 7 69	100	1/4" MESH BASKET	30.00	175.0	7.8	6.69	8570	15	0.75
4002	13 7 69	100	1/4" MESH BASKET	20.00	100.0	7.8	6.69	8570		
4003	13 7 69	100	1/4" MESH BASKET	20.00	15.0	7.8	6.69	8570		
4004	13 7 69	100	1/4" MESH BASKET	30.00	110.0	7.8	6.69	8570		
4101	13 7 69	120	1/4" MESH BASKET	30.00	1.0	7.9	6.76	8570		
4102	13 7 69	120	1/4" MESH BASKET	30.00	0.0	7.9	6.76	8570		
4201	13 7 69	110	1/4" MESH BASKET	30.00	0.0	7.8	6.69	8570		
4301	13 7 69	90	1/4" MESH BASKET	30.00	120.0	7.6	6.70	8570		
4302	13 7 69	90	1/4" MESH BASKET	30.00	25.0	7.6	6.70	8570		
4401	14 7 69	80	1/4" MESH BASKET	30.00	0.0	7.1	5.20	7450		
4402	14 7 69	80	1/4" MESH BASKET	30.00	0.0	7.1	5.20	7450		
4403	14 7 69	80	V. U. V.	30.00	10.0	7.1	5.20	7450		

TABLE IV-2 PAGE 3

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
4404	14 7 69	80	V. U. V.	30.00	15.0	7.1	5.20	7450		
4501	14 7 69	100	1/4" MESH BASKET	30.00	30.0	7.1	6.04	7450	16	0.52
4502	14 7 69	100	1/4" MESH BASKET	30.00	30.0	7.1	6.04	7450		
4503	14 7 69	100	V. U. V.	30.00	30.0	7.1	6.04	7450	17	0.28
4504	14 7 69	100	V. U. V.	30.00	60.0	7.1	6.04	7450	18	0.38
4601	14 7 69	90	1/4" MESH BASKET	30.00	35.0	7.0	5.78	7450		
4602	14 7 69	90	1/4" MESH BASKET	30.00	10.0	7.0	5.78	7450		
4701	14 7 69	120	V. U. V.	30.00	10.0	7.1	6.37	7450	19	0.02
4801	14 7 69	130	V. U. V.	30.00	10.0	7.1	6.75	7450	20	0.55
4901	29 7 69	80	1/4" MESH BASKET	30.00	25.0	6.3	7.47	9310		
4902	29 7 69	80	1/4" MESH BASKET	30.00	0.0	6.3	7.47	9310		
5001	29 7 69	100	1/4" MESH BASKET	30.00	125.0	6.6	7.86	9310		
5002	29 7 69	100	1/4" MESH BASKET	30.00	70.0	6.6	7.86	9310	21	1.30
5101	29 7 69	120	1/4" MESH BASKET	30.00	200.0	6.8	7.92	9310		
5102	29 7 69	120	1/4" MESH BASKET	20.00	205.0	6.8	7.92	9310	22	0.90
5201	29 7 69	140	1/4" MESH BASKET	30.00	55.0	7.1	8.17	9310		
5202	29 7 69	140	1/4" MESH BASKET	30.00	325.0	7.1	8.17	9310		
5203	29 7 69	140	1/4" MESH BASKET	15.00	300.0	7.1	8.17	9310		
5301	29 7 69	150	1/4" MESH BASKET	15.00	15.0	7.6	7.60	9310		
5401	29 7 69	160	1/4" MESH BASKET	20.00	140.0	8.1	7.94	9310		
5501	29 7 69	310	1/4" MESH BASKET	20.00	0.0	2.4	5.74	9310		
5601	30 7 69	180	1/4" MESH BASKET	30.00	0.0	9.2	4.62	8317		
5701	30 7 69	160	1/4" MESH BASKET	30.00	80.0	8.1	6.89	8317		
5702	30 7 69	160	1/4" MESH BASKET	30.00	80.0	8.1	6.89	8317	23	0.90
5801	30 7 69	140	1/4" MESH BASKET	30.00	5.0	6.9	7.17	8317		
5802	30 7 69	140	1/4" MESH BASKET	30.00	90.0	6.9	7.17	8317		
5803	30 7 69	140	1/4" MESH BASKET	30.00	180.0	6.9	7.17	8317		
5901	30 7 69	120	1/4" MESH BASKET	30.00	158.0	6.4	7.70	8317		
5902	30 7 69	120	1/4" MESH BASKET	30.00	10.0	6.4	7.70	8317		
5903	30 7 69	120	1/4" MESH BASKET	30.00	220.0	6.4	7.70	8317	24	0.95
6001	30 7 69	100	1/4" MESH BASKET	30.00	30.0	6.5	7.14	8317		
6002	30 7 69	100	1/4" MESH BASKET	30.00	20.0	6.5	7.14	8317		
6101	30 7 69	80	1/4" MESH BASKET	30.00	0.0	6.4	6.88	8317		
6202	30 7 69	70	1/4" MESH BASKET	30.00	0.0	6.0	6.81	8317		
6301	31 7 69	120	1/4" MESH BASKET	30.00	280.0	6.0	7.66	7470	25	0.50
6302	31 7 69	120	1/4" MESH BASKET	30.00	320.0	6.0	7.66	7470		0.50
6303	31 7 69	120	1/4" MESH BASKET	10.00	20.0	6.0	7.66	7470		
6304	31 7 69	120	1/4" MESH BASKET	20.00	15.0	6.0	7.66	7470		
6305	31 7 69	120	1/4" MESH BASKET	30.00	230.0	6.0	7.66	7470	26	0.50
6306	31 7 69	120	V. U. V.	20.00	50.0	6.0	7.66	7470	27	0.95
6307	31 7 69	120	V. U. V.	20.00	62.0	6.0	7.66	7470	28	1.10
6308	31 7 69	120	V. U. V.	20.00	70.0	6.0	7.66	7470	29	1.00
6309	31 7 69	120	V. U. V.	15.00	60.0	6.0	7.66	7470	30	0.80
6310	31 7 69	120	V. U. V.	15.00	75.0	6.0	7.66	7470	31	0.95
6311	31 7 69	120	1/2" MESH BASKET	30.00	300.0	6.0	7.66	7470	32	0.75
6312	31 7 69	120	1/2" MESH BASKET	20.00	170.0	6.0	7.66	7470	33	0.90
6313	31 7 69	120	1/2" MESH BASKET	20.00	345.0	6.0	7.66	7470		
6314	31 7 69	120	1/2" MESH BASKET	10.00	240.0	6.0	7.66	7470	34	0.90
6401	7 8 69	170	1/2" MESH BASKET	15.00	0.0	8.4	5.76	8120		
6501	7 8 69	160	1/2" MESH BASKET	30.00	30.0	8.3	6.79	8120		

TABLE IV-2 PAGE 4

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
6601	7 8 69	140	1/2" MESH BASKET	15.00	40.0	7.4	7.56	8120		
6602	7 8 69	140	1/2" MESH BASKET	30.00	200.0	7.4	7.56	8120	35	0.80
6603	7 8 69	140	1/4" MESH BASKET	20.00	0.0	7.4	7.56	8120		
6604	7 8 69	140	1/4" MESH BASKET	20.00	350.0	7.4	7.56	8120		
6605	7 8 69	140	1/4" MESH BASKET	15.00	80.0	7.4	7.56	8120		
6606	7 8 69	140	1/4" MESH BASKET	15.00	10.0	7.4	7.56	8120		
6701	7 8 69	120	1/4" MESH BASKET	16.00	80.0	7.0	7.84	8120		
6702	7 8 69	120	1/4" MESH BASKET	20.00	90.0	7.0	7.84	8120	36	1.45
6801	7 8 69	100	1/4" MESH BASKET	25.00	15.0	6.7	6.54	8120		
6802	7 8 69	100	1/4" MESH BASKET	30.00	170.0	6.7	6.54	8120		
6803	7 8 69	100	1/4" MESH BASKET	20.00	210.0	6.7	6.54	8120		
6901	7 8 69	80	1/4" MESH BASKET	30.00	5.0	6.7	6.63	8120		
6902	7 8 69	80	V. U. V.	20.00	15.0	6.7	6.63	8120	37	1.55
7001	7 8 69	70	1/4" MESH BASKET	20.00	15.0	6.4	5.89	8120		
7101	8 8 69	160	1/4" MESH BASKET	30.00	10.0	8.3	7.00	9166		
7201	8 8 69	140	1/4" MESH BASKET	20.00	165.0	7.7	7.57	9166		
7301	8 8 69	120	1/4" MESH BASKET	15.00	220.0	7.1	7.63	9166		
7302	8 8 69	120	1/4" MESH BASKET	15.00	150.0	7.1	7.63	9166		
7401	8 8 69	100	1/4" MESH BASKET	30.00	310.0	6.4	7.70	9166		
7501	8 8 69	80	1/4" MESH BASKET	30.00	2.0	6.8	7.01	9166		
7601	12 8 69	80	1/4" MESH BASKET	30.00	1.0	6.2	7.32	8150		
7701	12 8 69	100	1/4" MESH BASKET	20.00	175.0	6.5	7.33	8150		
7702	12 8 69	100	1/4" MESH BASKET	20.00	1.0	6.5	7.33	8150		
7703	12 8 69	100	1/4" MESH BASKET	20.00	65.0	6.5	7.33	8150	38	0.71
7801	12 8 69	120	1/4" MESH BASKET	30.00	15.0	6.0	7.79	8150		
7802	12 8 69	120	1/4" MESH BASKET	30.00	150.0	6.0	7.79	8150		
7803	12 8 69	120	1/4" MESH BASKET	30.00	300.0	6.0	7.79	8150		
7804	12 8 69	120	1/4" MESH BASKET	30.00	245.0	6.0	7.79	8150		
7805	12 8 69	120	1/4" MESH BASKET	20.00	185.0	6.0	7.79	8150	40	1.25
7308	12 8 69	120	1/4" MESH BASKET	20.00	120.0	6.0	7.79	8150		
7806	12 8 69	120	1/2" MESH BASKET	20.00	85.0	6.0	7.79	8150	41	0.80
7807	12 8 69	120	1/2" MESH BASKET	20.00	350.0	6.0	7.79	8150	42	1.35
7901	12 8 69	140	1/4" MESH BASKET	30.00	135.0	6.6	7.84	8150	39	1.10
7902	12 8 69	140	1/4" MESH BASKET	30.00	3.0	6.6	7.84	8150		
8001	12 8 69	160	1/4" MESH BASKET	30.00	14.0	8.0	6.46	8150		
8101	13 8 69	80	1/4" MESH BASKET	30.00	1.0	5.6	6.60	6800		
8201	13 8 69	100	1/4" MESH BASKET	60.00	130.0	5.8	6.74	6800	43	0.80
8301	13 8 69	120	1/4" MESH BASKET	30.00	205.0	6.3	7.44	6800		
8302	13 8 69	120	1/4" MESH BASKET	30.00	180.0	6.3	7.44	6800		
8303	13 8 69	120	1/4" MESH BASKET	20.00	45.0	6.3	7.44	6800		
8304	13 8 69	120	V. U. V.	20.00	60.0	6.3	7.44	6800		
8305	13 8 69	120	V. U. V.	20.00	20.0	6.3	7.44	6800		
8306	13 8 69	120	1/2" MESH BASKET	50.00	45.0	6.3	7.44	6800	44	1.70
8401	13 8 69	140	1/4" MESH BASKET	30.00	90.0	6.7	7.31	6800		
8402	13 8 69	140	1/4" MESH BASKET	33.00	15.0	6.7	7.31	6800		
8501	13 8 69	160	1/4" MESH BASKET	30.00	0.0	7.5	6.13	6800		
8601	13 8 69	150	1/4" MESH BASKET	15.00	5.0	7.3	6.77	6800		
8701	14 8 69	120	1/2" MESH BASKET	30.00	145.0	5.9	7.23	6169	45	1.20
8702	14 8 69	120	1/2" MESH BASKET	30.00	135.0	5.9	7.23	6169	46	1.25
8703	14 8 69	120	1/4" MESH BASKET	30.00	60.0	5.9	7.23	6169		

TABLE IV-2 PAGE 5

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	SAMPLE TIME (MIN.)	SAMPLE WEIGHT (LBS.)	DEPTH (FT.)	MEAN VELOCITY (FPS)	DISCHARGE (CFS)	SAMPLE ANALYSIS NUMBER	MEAN DIAMETER FROM ANALYSIS (INCHES)
8704	14 8 69	120	1/4" MESH BASKET	30.00	2.0	5.9	7.23	6169		
8705	14 8 69	120	1/4" MESH BASKET	30.00	195.0	5.9	7.23	6169	47	1.22
8801	14 8 69	140	1/4" MESH BASKET	30.00	60.0	6.5	6.84	6169		
28801	14 8 69	80	1/4" MESH BASKET	30.00	10.0	5.3	6.77	6169		
8901	14 8 69	100	1/4" MESH BASKET	30.00	145.0	5.4	6.84	6169		

TABLE V-15

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
12701	40	1/4" MESH BASKET	2997	0.0
11501	40	1/4" MESH BASKET	3370	0.0
11401	45	1/4" MESH BASKET	2205	0.0
15001	50	1/4" MESH BASKET	2083	11.1
15002	50	1/4" MESH BASKET	2083	34.2
15003	50	1/4" MESH BASKET	2083	24.4
15004	50	1/4" MESH BASKET	2083	20.0
15005	50	1/4" MESH BASKET	2083	20.4
15006	50	1/4" MESH BASKET	2083	14.4
9705	50	V. U. V.	2095	17.7
9706	50	V. U. V.	2095	25.0
9707	50	V. U. V.	2095	13.3
13914	50	1/4" MESH BASKET	2100	23.3
13915	50	1/4" MESH BASKET	2100	33.3
13907	50	V. U. V.	2100	27.7
13908	50	V. U. V.	2100	14.8
13909	50	V. U. V.	2100	24.4
13910	50	V. U. V.	2100	22.2
13911	50	V. U. V.	2100	29.6
13912	50	V. U. V.	2100	8.9
13913	50	V. U. V.	2100	24.4
14401	50	1/4" MESH BASKET	2100	15.5
14402	50	1/4" MESH BASKET	2100	31.1
10701	50	1/4" MESH BASKET	2219	26.6
10702	50	1/4" MESH BASKET	2219	25.5
10703	50	1/4" MESH BASKET	2219	8.8
10704	50	1/4" MESH BASKET	2219	8.8
10705	50	1/4" MESH BASKET	2233	12.2
9704	50	1/4" MESH BASKET	2261	2.7
13901	50	1/4" MESH BASKET	2270	31.6
13902	50	1/4" MESH BASKET	2270	36.1
13903	50	1/4" MESH BASKET	2270	29.1
13904	50	1/4" MESH BASKET	2270	17.0
13905	50	1/4" MESH BASKET	2270	27.7
13906	50	1/4" MESH BASKET	2270	38.2
10706	50	1/4" MESH BASKET	2380	10.0
9702	50	1/4" MESH BASKET	2395	16.6
9703	50	1/4" MESH BASKET	2395	18.5
10707	50	1/4" MESH BASKET	2410	2.2
9701	50	1/4" MESH BASKET	2455	25.5
13301	50	1/4" MESH BASKET	2493	0.1
13301	50	1/4" MESH BASKET	2535	0.1
9003	50	1/2" MESH BASKET	2845	38.0
12805	50	1/4" MESH BASKET	2876	12.9
9002	50	1/4" MESH BASKET	2890	16.6
9001	50	1/4" MESH BASKET	2970	4.4
12801	50	1/4" MESH BASKET	2997	63.8
12802	50	1/4" MESH BASKET	2997	16.6
12803	50	1/4" MESH BASKET	2997	50.0
12804	50	1/4" MESH BASKET	2997	62.9
12204	50	1/4" MESH BASKET	3102	85.1
12203	50	1/4" MESH BASKET	3122	44.4

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
12202	50	1/4" MESH BASKET	3144	49.6
12201	50	1/4" MESH BASKET	3165	45.4
11604	50	1/4" MESH BASKET	3180	41.6
11605	50	1/4" MESH BASKET	3180	72.2
11606	50	1/4" MESH BASKET	3190	30.5
11607	50	1/4" MESH BASKET	3180	103.6
11608	50	1/4" MESH BASKET	3180	105.5
11609	50	1/4" MESH BASKET	3180	111.1
9404	50	1/2" MESH BASKET	3186	0.2
9405	50	1/2" MESH BASKET	3186	0.6
9406	50	1/2" MESH BASKET	3186	11.4
9401	50	1/2" MESH BASKET	3250	6.6
9402	50	1/2" MESH BASKET	3250	19.3
9403	50	1/2" MESH BASKET	3282	44.1
11601	50	1/4" MESH BASKET	3370	122.2
11603	50	1/4" MESH BASKET	3390	55.5
11602	50	1/4" MESH BASKET	3410	11.1
10602	55	1/2" MESH BASKET	2247	6.2
10601	55	1/4" MESH BASKET	2261	15.5
15101	60	1/4" MESH BASKET	2083	1.1
15102	60	1/4" MESH BASKET	2083	15.2
15103	60	1/4" MESH BASKET	2083	0.3
15104	60	1/4" MESH BASKET	2083	2.7
15105	60	1/4" MESH BASKET	2083	1.8
15106	60	1/4" MESH BASKET	2083	0.1
9808	60	V. U. V.	2095	44.4
9809	60	V. U. V.	2095	55.5
9810	60	V. U. V.	2095	11.1
14016	60	1/4" MESH BASKET	2100	0.4
14017	60	1/4" MESH BASKET	2100	1.5
14018	60	1/4" MESH BASKET	2100	3.2
14019	60	1/4" MESH BASKET	2100	49.0
14020	60	1/4" MESH BASKET	2100	2.7
14021	60	1/4" MESH BASKET	2100	40.0
14013	60	V. U. V.	2100	16.0
14014	60	V. U. V.	2100	8.9
14015	60	V. U. V.	2100	22.2
14901	60	1/4" MESH BASKET	2100	68.8
14902	60	1/4" MESH BASKET	2100	19.0
14903	60	1/4" MESH BASKET	2100	17.4
14904	60	1/4" MESH BASKET	2100	0.9
14905	60	1/4" MESH BASKET	2100	9.5
14906	60	1/4" MESH BASKET	2100	0.9
14907	60	1/4" MESH BASKET	2100	6.9
14908	60	1/4" MESH BASKET	2100	0.9
14909	60	1/4" MESH BASKET	2100	7.9
14910	60	V. U. V.	2100	9.3
14911	60	V. U. V.	2100	31.7
14912	60	V. U. V.	2100	9.5
14913	60	V. U. V.	2100	25.0
14914	60	V. U. V.	2100	22.2
14915	60	V. U. V.	2100	9.5

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
14916	60	V. U. V.	2100	34.0
14917	60	V. U. V.	2100	29.6
14918	60	V. U. V.	2100	0.7
14919	60	V. U. V.	2100	50.8
14920	60	V. U. V.	2100	15.8
14012	60	1/4" MESH BASKET	2188	9.7
10804	60	1/4" MESH BASKET	2191	66.6
14009	60	1/4" MESH BASKET	2209	11.1
14010	60	1/4" MESH BASKET	2209	44.4
14011	60	1/4" MESH BASKET	2209	66.6
10801	60	1/4" MESH BASKET	2219	66.6
10802	60	1/4" MESH BASKET	2219	95.2
10803	60	1/4" MESH BASKET	2219	5.5
13211	60	1/4" MESH BASKET	2225	37.5
13210	60	1/4" MESH BASKET	2230	37.3
14005	60	1/4" MESH BASKET	2230	44.4
14006	60	1/4" MESH BASKET	2230	38.8
14007	60	1/4" MESH BASKET	2230	2.2
14008	60	1/4" MESH BASKET	2230	0.3
9806	60	1/2" MESH BASKET	2233	10.8
9807	60	1/2" MESH BASKET	2233	29.1
9805	60	1/2" MESH BASKET	2247	5.8
10805	60	1/4" MESH BASKET	2247	20.3
14001	60	1/4" MESH BASKET	2250	50.0
14002	60	1/4" MESH BASKET	2250	24.0
14003	60	1/4" MESH BASKET	2250	20.5
14004	60	1/4" MESH BASKET	2250	0.2
10806	60	1/4" MESH BASKET	2261	45.3
10807	60	1/4" MESH BASKET	2261	6.9
13212	60	1/4" MESH BASKET	2290	97.2
13213	60	1/4" MESH BASKET	2290	62.9
13214	60	1/4" MESH BASKET	2290	0.7
13215	60	1/4" MESH BASKET	2290	62.2
9803	60	1/4" MESH BASKET	2350	72.2
9804	60	1/4" MESH BASKET	2350	127.7
9802	60	1/4" MESH BASKET	2365	152.7
9801	60	1/4" MESH BASKET	2380	114.8
10808	60	1/4" MESH BASKET	2455	83.3
9601	60	1/4" MESH BASKET	2485	72.2
13207	60	1/4" MESH BASKET	2514	0.7
13208	60	1/4" MESH BASKET	2514	11.1
13209	60	1/4" MESH BASKET	2514	0.4
13205	60	1/4" MESH BASKET	2535	0.0
13206	60	1/4" MESH BASKET	2535	6.6
13202	60	1/4" MESH BASKET	2556	22.2
13203	60	1/4" MESH BASKET	2556	2.2
13204	60	1/4" MESH BASKET	2556	11.1
13201	60	1/4" MESH BASKET	2619	12.2
12906	60	1/4" MESH BASKET	2813	81.4
12904	60	1/4" MESH BASKET	2834	5.3
12905	60	1/4" MESH BASKET	2834	107.4
9103	60	1/2" MESH BASKET	2845	5.6

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
12902	60	1/4" MESH BASKET	2855	33.3
12903	60	1/4" MESH BASKET	2855	170.3
12908	60	1/4" MESH BASKET	2871	125.9
12901	60	1/4" MESH BASKET	2876	130.5
12907	60	1/4" MESH BASKET	2892	7.4
9102	60	1/4" MESH BASKET	2910	12.2
9101	60	1/4" MESH BASKET	2970	53.3
12306	60	1/4" MESH BASKET	3018	41.6
12304	60	1/4" MESH BASKET	3039	127.7
12305	60	1/4" MESH BASKET	3039	47.2
12303	60	1/4" MESH BASKET	3060	138.8
12301	60	1/4" MESH BASKET	3081	15.5
12302	60	1/4" MESH BASKET	3081	46.2
11704	60	1/4" MESH BASKET	3180	97.7
11705	60	1/4" MESH BASKET	3130	222.2
11706	60	1/4" MESH BASKET	3180	44.4
11707	60	1/4" MESH BASKET	3180	44.4
11702	60	1/4" MESH BASKET	3370	194.4
11703	60	1/4" MESH BASKET	3370	22.2
11701	60	1/4" MESH BASKET	3390	66.6
10401	65	1/4" MESH BASKET	2305	16.6
15202	70	1/4" MESH BASKET	2020	1.0
15201	70	1/4" MESH BASKET	2062	2.9
9909	70	V. U. V.	2095	33.3
9910	70	V. U. V.	2095	69.4
9911	70	V. U. V.	2095	2.2
14105	70	1/4" MESH BASKET	2100	0.3
14106	70	1/4" MESH BASKET	2100	0.2
14107	70	1/4" MESH BASKET	2100	0.2
14108	70	1/4" MESH BASKET	2100	0.1
14501	70	1/4" MESH BASKET	2100	19.2
14502	70	1/4" MESH BASKET	2100	8.8
14503	70	1/4" MESH BASKET	2100	0.1
14504	70	1/4" MESH BASKET	2100	5.5
14505	70	1/4" MESH BASKET	2100	0.3
14506	70	1/4" MESH BASKET	2100	6.6
14507	70	1/4" MESH BASKET	2100	12.7
14104	70	1/4" MESH BASKET	2146	21.5
14101	70	1/4" MESH BASKET	2167	1.8
14102	70	1/4" MESH BASKET	2167	18.8
14103	70	1/4" MESH BASKET	2167	3.3
10904	70	1/4" MESH BASKET	2205	22.2
9907	70	1/2" MESH BASKET	2219	41.6
9908	70	1/2" MESH BASKET	2219	80.5
10901	70	1/4" MESH BASKET	2219	19.4
10902	70	1/4" MESH BASKET	2219	19.4
10903	70	1/4" MESH BASKET	2219	16.6
9905	70	1/2" MESH BASKET	2233	1.6
9906	70	1/2" MESH BASKET	2233	45.8
13413	70	1/4" MESH BASKET	2250	46.6
10905	70	1/4" MESH BASKET	2275	35.1
13412	70	1/4" MESH BASKET	2290	211.1

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
10906	70	1/4" MESH BASKET	2305	25.9
13410	70	1/4" MESH BASKET	2310	8.8
13411	70	1/4" MESH BASKET	2310	44.4
13408	70	1/4" MESH BASKET	2330	5.5
13409	70	1/4" MESH BASKET	2330	87.0
9904	70	1/4" MESH BASKET	2335	38.8
10907	70	1/4" MESH BASKET	2335	83.3
9901	70	1/4" MESH BASKET	2350	44.4
9902	70	1/4" MESH BASKET	2350	255.5
9903	70	1/4" MESH BASKET	2350	11.1
13406	70	1/4" MESH BASKET	2350	0.3
13407	70	1/4" MESH BASKET	2350	70.3
13403	70	1/4" MESH BASKET	2493	64.8
13404	70	1/4" MESH BASKET	2493	80.5
13405	70	1/4" MESH BASKET	2493	34.5
13401	70	1/4" MESH BASKET	2514	16.6
13402	70	1/4" MESH BASKET	2514	53.3
13005	70	1/4" MESH BASKET	2787	72.2
13006	70	1/4" MESH BASKET	2787	111.1
13007	70	1/4" MESH BASKET	2787	1.4
13008	70	1/4" MESH BASKET	2787	55.5
13009	70	1/4" MESH BASKET	2787	128.8
13010	70	1/4" MESH BASKET	2787	115.5
13004	70	1/4" MESH BASKET	2808	0.7
13011	70	1/4" MESH BASKET	2808	5.3
13003	70	1/4" MESH BASKET	2829	1.6
9203	70	1/2" MESH BASKET	2845	2.3
13002	70	1/4" MESH BASKET	2850	2.2
13001	70	1/4" MESH BASKET	2871	0.7
9202	70	1/4" MESH BASKET	2910	3.7
9201	70	1/4" MESH BASKET	2990	111.1
12402	70	1/4" MESH BASKET	2997	41.6
12403	70	1/4" MESH BASKET	2997	5.5
12404	70	1/4" MESH BASKET	2997	75.0
12405	70	1/4" MESH BASKET	2997	86.1
12409	70	1/4" MESH BASKET	2997	92.5
12401	70	1/4" MESH BASKET	3018	0.5
12406	70	1/4" MESH BASKET	3018	52.7
12407	70	1/4" MESH BASKET	3018	155.5
12408	70	1/4" MESH BASKET	3018	66.6
11903	70	1/4" MESH BASKET	3180	22.2
11904	70	1/4" MESH BASKET	3180	17.7
11905	70	1/4" MESH BASKET	3180	172.2
11906	70	1/4" MESH BASKET	3180	204.4
11907	70	1/4" MESH BASKET	3180	1.1
11908	70	1/4" MESH BASKET	3180	14.8
9501	70	1/2" MESH BASKET	3186	69.4
9502	70	1/2" MESH BASKET	3186	1.6
9503	70	1/2" MESH BASKET	3186	87.5
9504	70	1/2" MESH BASKET	3186	135.4
9505	70	1/2" MESH BASKET	3186	160.0
11901	70	1/4" MESH BASKET	3330	0.0

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
11902	70	1/4" MESH BASKET	3330	55.5
15301	80	1/4" MESH BASKET	1980	0.7
15302	80	1/4" MESH BASKET	1980	3.7
10010	80	V. U. V.	2095	3.3
14205	80	1/4" MESH BASKET	2100	0.2
14206	80	1/4" MESH BASKET	2100	0.1
14601	80	1/4" MESH BASKET	2100	0.1
14602	80	1/4" MESH BASKET	2100	0.1
14603	80	1/4" MESH BASKET	2100	1.5
14604	80	1/4" MESH BASKET	2100	1.6
14203	80	1/4" MESH BASKET	2125	9.3
14204	80	1/4" MESH BASKET	2125	12.2
14201	80	1/4" MESH BASKET	2146	9.3
14202	80	1/4" MESH BASKET.	2146	5.3
10009	80	1/2" MESH BASKET	2163	12.5
10007	80	1/2" MESH BASKET	2191	2.0
10008	80	1/2" MESH BASKET	2191	27.7
10006	80	1/2" MESH BASKET	2205	44.4
11001	80	1/4" MESH BASKET	2205	16.6
11002	80	1/4" MESH BASKET	2205	80.5
11003	80	1/4" MESH BASKET	2205	15.2
10005	80	1/2" MESH BASKET	2219	73.3
10001	80	1/4" MESH BASKET	2335	144.4
10002	80	1/4" MESH BASKET	2335	2.2
10003	80	1/4" MESH BASKET	2335	60.5
10004	80	1/4" MESH BASKET	2335	16.6
13510	80	1/4" MESH BASKET	2350	51.8
13511	80	1/4" MESH BASKET	2350	50.0
13512	80	1/4" MESH BASKET	2350	33.8
13513	80	1/4" MESH BASKET	2350	96.2
13514	80	1/4" MESH BASKET	2350	3.7
13504	80	1/4" MESH BASKET	2370	14.8
13505	80	1/4" MESH BASKET	2370	27.7
13506	80	1/4" MESH BASKET	2370	75.9
13507	80	1/4" MESH BASKET	2370	29.6
13508	80	1/4" MESH BASKET	2370	25.9
13509	80	1/4" MESH BASKET	2370	35.1
13501	80	1/4" MESH BASKET	2493	49.1
13502	80	1/4" MESH BASKET	2493	68.5
13503	80	1/4" MESH BASKET	2493	2.7
13101	80	1/4" MESH BASKET	2808	18.5
13102	80	1/4" MESH BASKET	2808	0.3
13103	80	1/4" MESH BASKET	2808	55.5
13104	80	1/4" MESH BASKET	2808	177.7
9302	80	1/2" MESH BASKET	2845	79.1
12502	80	1/4" MESH BASKET	2876	5.5
12503	80	1/4" MESH BASKET	2876	52.3
9301	80	1/2" MESH BASKET	2890	157.7
12501	80	1/4" MESH BASKET	2997	0.0
12504	80	1/4" MESH BASKET	2997	55.5
12505	80	1/4" MESH BASKET	2997	33.3
12506	80	1/4" MESH BASKET	2997	66.6

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
11803	80	1/4" MESH BASKET	3180	22.2
11804	80	1/4" MESH BASKET	3180	66.6
11805	80	1/4" MESH BASKET	3180	0.9
11806	80	1/4" MESH BASKET	3180	18.5
11807	80	1/4" MESH BASKET	3180	109.2
11808	80	1/4" MESH BASKET	3180	4.4
11809	80	1/4" MESH BASKET	3180	18.5
11801	80	1/4" MESH BASKET	3350	5.5
11802	80	1/4" MESH BASKET	3350	11.1
15401	90	1/4" MESH BASKET	1960	0.5
15402	90	1/4" MESH BASKET	1960	1.1
14302	90	1/4" MESH BASKET	2083	0.1
14303	90	1/4" MESH BASKET	2100	0.0
14701	90	1/4" MESH BASKET	2100	2.9
14702	90	1/4" MESH BASKET	2100	0.7
14703	90	1/4" MESH BASKET	2100	2.2
10109	90	1/2" MESH BASKET	2121	0.0
10110	90	1/2" MESH BASKET	2121	0.0
14301	90	1/4" MESH BASKET	2125	0.2
10108	90	1/2" MESH BASKET	2163	6.6
10106	90	1/2" MESH BASKET	2171	0.0
10107	90	1/2" MESH BASKET	2171	1.6
10105	90	1/2" MESH BASKET	2191	0.0
11101	90	1/4" MESH BASKET	2205	41.1
11102	90	1/4" MESH BASKET	2205	4.4
11103	90	1/4" MESH BASKET	2205	37.0
10104	90	1/4" MESH BASKET	2305	3.7
10101	90	1/4" MESH BASKET	2335	1.1
10102	90	1/4" MESH BASKET	2335	0.5
10103	90	1/4" MESH BASKET	2335	19.4
13608	90	1/4" MESH BASKET	2390	26.1
13605	90	1/4" MESH BASKET	2410	5.5
13606	90	1/4" MESH BASKET	2410	11.6
13607	90	1/4" MESH BASKET	2410	19.4
13604	90	1/4" MESH BASKET	2430	4.0
13601	90	1/4" MESH BASKET	2493	3.7
13602	90	1/4" MESH BASKET	2493	3.3
13603	90	1/4" MESH BASKET	2493	22.2
12601	90	1/4" MESH BASKET	2997	0.0
12001	90	1/4" MESH BASKET	3180	4.4
12002	90	1/4" MESH BASKET	3180	1.8
13801	95	1/4" MESH BASKET	2410	1.1
15501	100	1/4" MESH BASKET	1960	0.0
14801	100	1/4" MESH BASKET	2100	0.0
10202	100	1/2" MESH BASKET	2135	0.0
10203	100	1/2" MESH BASKET	2135	0.0
11202	100	1/4" MESH BASKET	2191	0.0
11201	100	1/4" MESH BASKET	2205	0.4
10201	100	1/4" MESH BASKET	2305	2.7
13702	100	1/4" MESH BASKET	2410	0.0
13701	100	1/4" MESH BASKET	2493	0.0
12101	100	1/4" MESH BASKET	3180	0.0

BED LOAD SAMPLES
SORTED BY STATION & INCREASING DISTANCE

SAMPLE I.D.	STATION	SAMPLER TYPE	FLUID DISCHARGE	BED LOAD DISCHARGE
10303	110	1/2" MESH BASKET	2135	0.4
10302	110	1/2" MESH BASKET	2142	0.0
11301	110	1/4" MESH BASKET	2191	0.0
10301	110	1/4" MESH BASKET	2305	0.0

TABLE V-17

BED LOAD ANALYSIS

ELBOW RIVER AT BRAGG CREEK

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	TOTAL SAMPLING TIME (MIN.)	TOTAL SAMPLING WEIGHT (LBS.)	UNIT BED LOAD ASSUMING 100% EFFICIENT SAMPLERS	ACTUAL UNIT BED LOAD DISCHARGE (LBS./FT.MIN.)	DEPTH (FT.)	MEAN VELOCITY (FT./SEC.)	DISCHARGE (CFS)	MEAN DIAM. USED FOR ANALYSIS (INCHES)
901	25 6 69	50	1/4" MESH BASKET	7.00	50.0	3.57	7.94	2.7	6.42	2930	0.50
902	25 6 69	50	1/2" MESH BASKET	5.00	228.0	22.80	38.00	2.7	6.42	2845	0.50
911	25 6 69	60	1/4" MESH BASKET	7.00	262.0	18.71	41.59	2.7	9.00	2940	1.00
912	25 6 69	60	1/2" MESH BASKET	5.00	34.0	3.40	5.67	2.7	9.00	2845	1.00
921	25 6 69	70	1/4" MESH BASKET	4.50	305.0	33.89	75.31	2.6	9.58	2950	1.50
922	25 6 69	70	1/2" MESH BASKET	5.00	14.0	1.40	2.33	2.6	9.58	2845	1.50
931	25 6 69	80	1/4" MESH BASKET	0.75	142.0	94.67	210.37	3.3	10.32	2890	1.50
932	25 6 69	80	1/2" MESH BASKET	3.00	285.0	47.50	79.17	3.3	10.32	2845	1.50
942	26 6 69	50	1/2" MESH BASKET	37.00	652.0	8.81	14.68	3.5	6.98	3223	0.50
952	26 6 69	70	1/2" MESH BASKET	11.25	1134.0	50.40	84.00	3.5	9.54	3186	1.50
961	27 6 69	60	1/4" MESH BASKET	4.00	260.0	32.50	72.22	2.6	7.73	2485	1.00
971	27 6 69	50	1/4" MESH BASKET	20.00	300.0	7.50	16.67	2.5	5.35	2377	0.50
973	27 6 69	50	V. U. V.	14.00	115.0	5.48	18.25	2.5	5.35	2095	0.50
981	27 6 69	60	1/4" MESH BASKET	7.00	765.0	54.64	121.43	2.6	7.73	2361	1.00
982	27 6 69	60	1/2" MESH BASKET	25.00	515.0	10.30	17.17	2.6	7.73	2238	1.00
983	27 6 69	60	V. U. V.	13.00	220.0	11.28	37.61	2.6	7.73	2095	1.00
991	27 6 69	70	1/4" MESH BASKET	4.50	235.0	26.11	58.02	2.9	8.43	2346	1.50
992	27 6 69	70	1/2" MESH BASKET	15.00	[illegible]	22.50	37.50	2.9	8.43	2226	1.50
993	27 6 69	70	V. U. V.	13.00	204.0	10.46	34.87	2.9	8.43	2095	1.50
1001	27 6 69	60	1/4" MESH BASKET	6.00	307.0	25.58	56.85	2.8	9.27	2335	1.50
1002	27 6 69	80	1/2" MESH BASKET	13.00	465.0	17.88	29.81	2.8	9.27	2194	1.50
1003	27 6 69	80	V. U. V.	4.00	15.0	2.50	8.33	2.8	9.27	2095	1.50
1011	27 6 69	90	1/4" MESH BASKET	8.00	47.0	2.94	6.53	3.5	7.38	2328	1.50
1012	27 6 69	90	1/2" MESH BASKET	23.00	42.0	0.91	1.52	3.5	7.38	2156	1.50
1021	27 6 69	100	1/4" MESH BASKET	4.00	10.0	1.25	2.78	4.3	7.51	2305	1.50
1022	27 6 69	100	1/2" MESH BASKET	10.00	0.5	0.02	0.04	4.3	7.51	2135	1.50
1031	27 6 69	110	1/4" MESH BASKET	1.50	0.0	0.0	0.0	4.2	7.81	2305	1.50
1032	27 6 69	110	1/2" MESH BASKET	8.50	2.0	0.12	0.20	4.2	7.81	2142	1.50
1041	27 6 69	45	1/4" MESH BASKET	3.00	45.0	7.50	16.67	2.6	7.92	2305	1.25
1051	27 6 69	40	1/4" MESH BASKET	8.00	1.0	0.06	0.14	1.4	3.18	2275	1.50
1061	27 6 69	55	1/4" MESH BASKET	5.00	70.0	7.00	15.56	2.8	6.35	2261	0.75
1062	27 6 69	55	1/2" MESH BASKET	10.00	75.0	3.75	6.25	2.8	6.35	2247	0.75
1071	28 6 69	50	1/4" MESH BASKET	35.00	425.0	6.07	13.49	2.7	5.16	2271	0.50
1081	28 6 69	60	1/4" MESH BASKET	28.00	1295.0	23.13	51.39	2.4	7.73	2259	1.00
1091	28 6 69	70	1/4" MESH BASKET	20.00	640.0	16.00	35.56	2.3	7.77	2254	1.50
1101	28 6 69	80	1/4" MESH BASKET	[illegible]	405.0	[illegible]	37.50	2.5	8.11	2205	1.50
1111	28 6 69	90	1/4" MESH BASKET	13.00	305.0	11.73	26.07	3.2	7.96	2205	1.50
1121	28 6 69	100	1/4" MESH BASKET	10.00	2.0	0.10	0.22	4.1	7.60	2198	1.50
1131	28 6 69	110	1/4" MESH BASKET	5.00	0.0	0.0	0.0	4.7	7.39	2191	1.50
1141	28 6 69	[illegible]	1/4" MESH BASKET	10.00	0.0	0.0	0.0	2.2	4.20	2205	0.50
1151	30 6 69	40	1/4" MESH BASKET	4.00	0.0	0.0	0.0	2.4	5.00	3370	1.50
1161	30 6 69	50	1/4" MESH BASKET	26.00	1910.0	36.73	81.62	4.5	9.12	3250	0.50
1171	30 6 69	60	1/4" MESH BASKET	7.50	695.0	46.33	102.96	3.3	9.57	3264	1.00
1181	30 6 69	80	1/4" MESH BASKET	19.75	625.0	15.82	35.16	3.5	10.90	3218	1.50
1191	30 6 69	70	1/4" MESH BASKET	11.00	701.0	31.86	70.81	3.9	9.50	3218	1.50
1201	30 6 69	90	1/4" MESH BASKET	14.00	35.0	1.25	2.78	3.4	8.56	3180	1.50
1211	30 6 69	100	1/4" MESH BASKET	5.00	0.0	0.0	0.0	4.9	7.00	3180	1.50
[illegible]	[illegible]	[illegible]	1/4" MESH BASKET	[illegible]	[illegible]	[illegible]	[illegible]	4.1	9.75	3124	0.50

TABLE V-18

BED LOAD ANALYSIS

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	TOTAL SAMPLING TIME (MIN.)	TOTAL SAMPLING WEIGHT (LBS.)	UNIT BED LOAD ASSUMING 100% EFFICIENT SAMPLERS	ACTUAL UNIT BED LOAD DISCHARGE (LBS./FT.MIN.)	DEPTH (FT.)	MEAN VELOCITY (FT./SEC.)	DISCHARGE (CFS)	MEAN DIAM. USED FOR ANALYSIS (INCHES)
11	24 6 69	46	1/4" MESH BASKET	10.00	0.0	0.0	0.0	3.6	3.16	10358	0.75
21	24 6 69	55	1/4" MESH BASKET	10.00	0.0	0.0	0.0	5.5	5.91	10358	0.75
31	24 6 69	62	1/4" MESH BASKET	50.00	251.0	2.51	5.58	6.7	7.09	10358	0.75
41	24 6 69	80	1/4" MESH BASKET	31.00	0.0	0.0	0.0	6.3	6.55	10358	0.75
51	24 6 69	100	1/4" MESH BASKET	37.00	103.0	1.39	3.09	5.1	6.78	10358	0.75
61	24 6 69	120	1/4" MESH BASKET	20.00	450.0	11.25	25.00	5.6	7.60	10358	0.75
71	24 6 69	140	1/4" MESH BASKET	20.00	340.0	8.50	18.89	6.6	6.44	10358	0.75
81	24 6 69	160	1/4" MESH BASKET	20.00	85.0	2.13	4.72	7.9	7.18	10358	0.75
91	24 6 69	180	1/4" MESH BASKET	30.00	2.0	0.03	0.07	3.9	5.74	10358	0.75
101	24 6 69	255	1/4" MESH BASKET	10.00	0.0	0.0	0.0	3.9	5.74	10358	0.75
111	8 7 69	60	1/4" MESH BASKET	20.00	0.0	0.0	0.0	5.8	6.25	10700	0.75
121	8 7 69	80	1/4" MESH BASKET	30.00	470.0	7.83	17.41	7.2	8.12	10700	0.75
131	8 7 69	100	1/4" MESH BASKET	25.00	11.0	0.22	0.49	7.6	7.28	10700	0.75
141	8 7 69	120	1/4" MESH BASKET	25.00	10.0	0.20	0.44	8.3	7.95	10700	0.75
151	8 7 69	140	1/4" MESH BASKET	25.00	2.0	0.04	0.09	7.6	6.76	10700	0.75
161	8 7 69	160	1/4" MESH BASKET	25.00	1.0	0.02	0.04	8.4	6.87	10700	0.75
171	9 7 69	60	1/4" MESH BASKET	20.00	0.0	0.0	0.0	6.3	5.93	11400	0.75
181	9 7 69	80	1/4" MESH BASKET	75.00	329.0	2.19	4.87	9.0	8.05	11400	0.75
191	9 7 69	100	1/4" MESH BASKET	30.00	35.0	0.58	1.30	7.9	7.49	11400	0.75
201	9 7 69	120	1/4" MESH BASKET	30.00	110.0	1.83	4.07	8.6	7.86	11400	0.75
211	9 7 69	140	1/4" MESH BASKET	30.00	0.0	0.0	0.0	7.7	7.22	11400	0.75
221	9 7 69	160	1/4" MESH BASKET	50.00	0.0	0.0	0.0	8.7	6.99	11400	0.75
233	9 7 69	55	V. U. V.	30.00	85.0	1.89	6.30	4.0	5.85	11400	0.75
241	10 7 69	60	1/4" MESH BASKET	20.00	0.0	0.0	0.0	6.2	6.36	11900	0.75
251	10 7 69	80	1/4" MESH BASKET	140.00	739.0	2.64	5.87	8.3	7.75	11900	0.75
261	10 7 69	100	1/4" MESH BASKET	100.00	140.0	0.70	1.56	8.3	7.85	11900	0.75
271	10 7 69	120	1/4" MESH BASKET	80.00	260.0	1.75	3.89	9.5	8.03	11900	0.75
281	10 7 69	140	1/4" MESH BASKET	30.00	1.0	0.02	0.04	8.1	7.20	11900	0.75
291	10 7 69	175	1/4" MESH BASKET	30.00	0.0	0.0	0.0	10.1	5.86	11900	0.75
2271	11 7 69	60	1/4" MESH BASKET	20.00	0.0	0.0	0.0	6.4	5.96	12300	0.75
2281	11 7 69	80	1/4" MESH BASKET	155.00	455.0	1.47	3.26	9.0	7.68	12300	0.75
[illegible]	11 7 69	[illegible]	V. U. V.	[illegible]	[illegible]	0.96	3.21	9.0	7.68	12300	0.75
2291	11 7 69	100	1/4" MESH BASKET	30.00	250.0	4.17	9.26	8.3	7.41	12300	0.75
301	11 7 69	120	1/4" MESH BASKET	30.00	25.0	0.42	0.93	9.2	7.60	12300	0.75
311	11 7 69	140	1/4" MESH BASKET	30.00	0.0	0.0	0.0	8.1	7.47	12300	0.75
[illegible]	[illegible] 7 69	[illegible]	1/4" MESH BASKET	[illegible]	167.0	0.70	1.55	8.2	7.41	10800	0.75
331	12 7 69	100	1/4" MESH BASKET	40.00	95.0	1.19	2.64	8.3	7.37	10800	0.75
341	12 7 69	130	1/4" MESH BASKET	60.00	1.0	0.01	0.02	8.6	7.61	10800	0.75
351	12 7 69	170	1/4" MESH BASKET	60.00	190.0	1.58	3.52	8.1	7.29	10800	0.75
361	12 7 69	150	1/4" MESH BASKET	30.00	0.0	0.0	0.0	7.6	7.28	10800	0.75
371	12 7 69	200	1/4" MESH BASKET	30.00	5.0	0.08	0.19	4.6	4.86	10800	0.75
381	12 7 69	350	1/4" MESH BASKET	30.00	0.0	0.0	0.0	9.4	5.65	10800	0.75
391	13 7 69	80	1/4" MESH BASKET	120.00	395.0	1.65	3.66	7.5	7.07	8570	0.75
401	13 7 69	[illegible]	1/4" MESH BASKET	100.00	400.0	2.00	4.44	7.8	6.69	8570	0.75
411	13 7 69	100	1/4" MESH BASKET	60.00	1.0	0.01	0.02	7.9	6.76	8570	0.75
421	13 7 69	110	1/4" MESH BASKET	30.00	0.0	0.0	0.0	7.8	6.69	8570	0.75
431	13 7 69	90	1/4" MESH BASKET	60.00	145.0	1.21	2.69	7.6	6.70	8570	0.75
441	14 7 69	[illegible]	1/4" MESH BASKET	40.00	0.0	0.0	0.0	7.1	5.20	7450	0.75

TABLE V-18 PAGE 2

BED LOAD ANALYSIS

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	TOTAL SAMPLING TIME (MIN.)	TOTAL SAMPLING WEIGHT (LBS.)	UNIT BED LOAD ASSUMING 100% EFFICIENT SAMPLERS	ACTUAL UNIT BED LOAD DISCHARGE (LBS./FT.MIN.)	DEPTH (FT.)	MEAN VELOCITY (FT./SEC.)	DISCHARGE (CFS)	MEAN DIAM. USED FOR ANALYSIS (INCHES)
442	14 7 69	80	V. U. V.	60.00	25.0	0.28	0.93	7.1	5.20	7450	0.75
451	14 7 69	100	1/4" MESH BASKET	60.00	60.0	0.50	1.11	7.1	6.04	7450	0.75
452	14 7 69	100	V. U. V.	60.00	90.0	1.00	3.33	7.1	6.04	7450	0.75
461	14 7 69	[illegible]	1/4" MESH BASKET	60.00	45.0	0.38	0.83	7.0	5.78	7450	0.75
472	14 7 69	120	V. U. V.	30.00	10.0	0.22	0.74	7.1	6.37	7450	0.75
482	14 7 69	130	V. U. V.	30.00	10.0	0.22	0.74	7.1	6.75	7450	0.75
491	29 7 69	80	1/4" MESH BASKET	60.00	25.0	0.21	0.46	6.3	7.47	9310	0.75
501	29 7 69	100	1/4" MESH BASKET	60.00	195.0	1.63	3.61	6.6	7.86	9310	0.75
511	29 7 69	120	1/4" MESH BASKET	50.00	415.0	4.15	9.20	6.8	7.92	9310	0.75
521	29 7 69	140	1/4" MESH BASKET	75.00	680.0	4.53	10.07	7.1	8.17	9310	0.75
531	29 7 69	150	1/4" MESH BASKET	15.00	15.0	0.50	1.11	7.6	7.60	9310	0.75
541	29 7 69	160	1/4" MESH BASKET	20.00	140.0	3.50	7.78	8.1	7.94	9310	0.75
551	29 7 69	310	1/4" MESH BASKET	20.00	0.0	0.0	0.0	9.4	5.74	9310	0.75
561	30 7 69	120	1/4" MESH BASKET.	30.00	0.0	0.0	0.0	9.2	4.62	8317	0.75
571	30 7 69	160	1/4" MESH BASKET	60.00	160.0	1.33	2.96	6.1	6.99	8317	0.75
581	30 7 69	140	1/4" MESH BASKET	90.00	275.0	1.53	3.40	6.9	7.17	8317	0.75
591	30 7 69	120	1/4" MESH BASKET	90.00	388.0	2.16	4.79	6.4	7.70	8317	0.75
601	30 7 69	100	1/4" MESH BASKET	60.00	50.0	0.42	0.93	6.5	7.14	8317	0.75
611	30 7 69	90	1/4" MESH BASKET	30.00	0.0	0.0	0.0	6.4	6.98	8317	0.75
621	30 7 69	70	1/4" MESH BASKET	30.00	0.0	0.0	0.0	6.0	6.81	8317	0.75
631	31 7 69	120	1/4" MESH BASKET	120.00	865.0	3.60	8.01	6.0	7.66	7470	0.75
633	31 7 69	120	V. U. V.	90.00	317.0	2.35	7.83	6.0	7.66	7470	0.75
632	31 7 69	120	1/2" MESH BASKET	80.00	1055.0	6.59	10.39	6.0	7.66	7470	0.75
642	7 8 69	170	1/2" MESH BASKET	15.00	0.0	0.0	0.0	8.4	5.76	8120	0.75
652	7 8 69	160	1/2" MESH BASKET	30.00	30.0	0.50	0.83	8.3	6.79	8120	0.75
662	7 8 69	140	1/2" MESH BASKET	45.00	240.0	2.67	4.44	7.4	7.56	8120	0.75
661	7 8 69	140	1/4" MESH BASKET	70.00	440.0	3.14	6.98	7.4	7.56	8120	0.75
671	7 8 69	120	1/4" MESH BASKET	36.00	170.0	2.36	5.25	7.0	7.84	8120	0.75
681	7 8 69	100	1/4" MESH BASKET	75.00	395.0	2.63	5.85	6.7	6.54	8120	0.75
691	7 8 69	90	1/4" MESH BASKET	30.00	5.0	0.08	0.19	6.7	6.63	8120	0.75
692	7 8 69	80	V. U. V.	20.00	15.0	0.50	1.67	6.7	6.63	8120	0.75
701	7 8 69	70	1/4" MESH BASKET	20.00	15.0	0.38	0.83	6.4	6.89	8120	0.75
711	8 8 69	160	1/4" MESH BASKET	30.00	10.0	0.17	0.37	8.3	7.00	9166	0.75
721	8 8 69	140	1/4" MESH BASKET	20.00	165.0	4.13	9.17	7.7	7.57	9166	0.75
731	9 8 69	120	1/4" MESH BASKET	30.00	370.0	6.17	13.70	7.1	7.63	9166	0.75
741	9 8 69	100	1/4" MESH BASKET	30.00	310.0	5.17	11.48	6.4	7.70	9166	0.75
751	9 8 69	70	1/4" MESH BASKET	30.00	2.0	0.03	0.07	6.8	7.01	9166	0.75
761	12 8 69	80	1/4" MESH BASKET	30.00	1.0	0.02	0.04	6.2	7.32	8150	0.75
771	12 8 69	100	1/4" MESH BASKET	60.00	241.0	2.01	4.46	6.5	7.33	8150	0.75
781	12 8 69	120	1/4" MESH BASKET	160.00	1015.0	3.17	7.05	6.0	7.77	8150	0.75
782	12 8 69	120	1/2" MESH BASKET	40.00	435.0	5.44	9.06	6.0	7.79	8150	0.75
791	12 8 69	140	1/4" MESH BASKET	60.00	138.0	1.15	2.55	6.6	7.84	8150	0.75
801	12 8 69	160	1/4" MESH BASKET	30.00	14.0	0.23	0.52	8.0	6.46	8150	0.75
811	13 8 69	80	1/4" MESH BASKET	30.00	1.0	0.02	0.04	5.6	6.60	6800	0.75
821	13 8 69	100	1/4" MESH BASKET	60.00	130.0	1.08	2.41	5.8	6.74	6800	0.75
831	13 8 69	120	1/4" MESH BASKET	80.00	430.0	2.69	5.97	6.3	7.44	6800	0.75
833	13 8 69	120	V. U. V.	40.00	60.0	1.33	4.44	6.3	7.44	6800	0.75
832	13 8 69	120	1/2" MESH BASKET	50.00	45.0	0.45	0.75	6.3	7.44	6800	0.75

THE UNIVERSITY OF ALBERTA

TABLE V-18 PAGE 3

BED LOAD ANALYSIS

NORTH SASKATCHEWAN RIVER AT NORDEGG BRIDGE

SAMPLE I.D. NUMBER	DATE	STATION (FT.)	SAMPLER TYPE	TOTAL SAMPLING TIME (MIN.)	TOTAL SAMPLING WEIGHT (LBS.)	UNIT BED LOAD ASSUMING 100% EFFICIENT SAMPLERS	ACTUAL UNIT BED LOAD DISCHARGE (LBS./FT.MIN.)	DEPTH (FT.)	MEAN VELOCITY (FT./SEC.)	DISCHARGE (CFS)	MEAN DIAM. USED FOR ANALYSIS (INCHES)
[illegible]	13 8 69	140	1/4' MESH BASKET	63.00	105.0	0.83	1.95	6.7	7.31	6800	0.75
[illegible]	13 8 69	160	1/4" MESH BASKET	30.00	0.0	0.0	0.0	7.5	6.13	6800	0.75
851	13 8 69	150	1/4' MESH BASKET	15.00	5.0	0.17	0.37	7.3	6.77	6800	0.75
870	14 8 69	120	1/4' MESH BASKET	60.00	280.0	2.33	3.89	5.9	7.23	6169	0.75
[illegible]	14 8 69	120	1/4" MESH BASKET	90.00	257.0	1.43	3.17	5.9	7.23	6169	0.75
[illegible]	14 8 69	140	1/4" MESH BASKET	30.00	60.0	1.00	2.22	6.5	6.84	6169	0.75
[illegible]	14 8 69	80	1/4' MESH BASKET	30.00	10.0	0.17	0.37	5.3	6.77	6169	0.75
[illegible]	14 [illegible]	[illegible]	1/4" MESH BASKET	30.[illegible]	145.0	2.42	5.37	5.4	6.94	3085	0.75

APPENDIX B

FIGURES

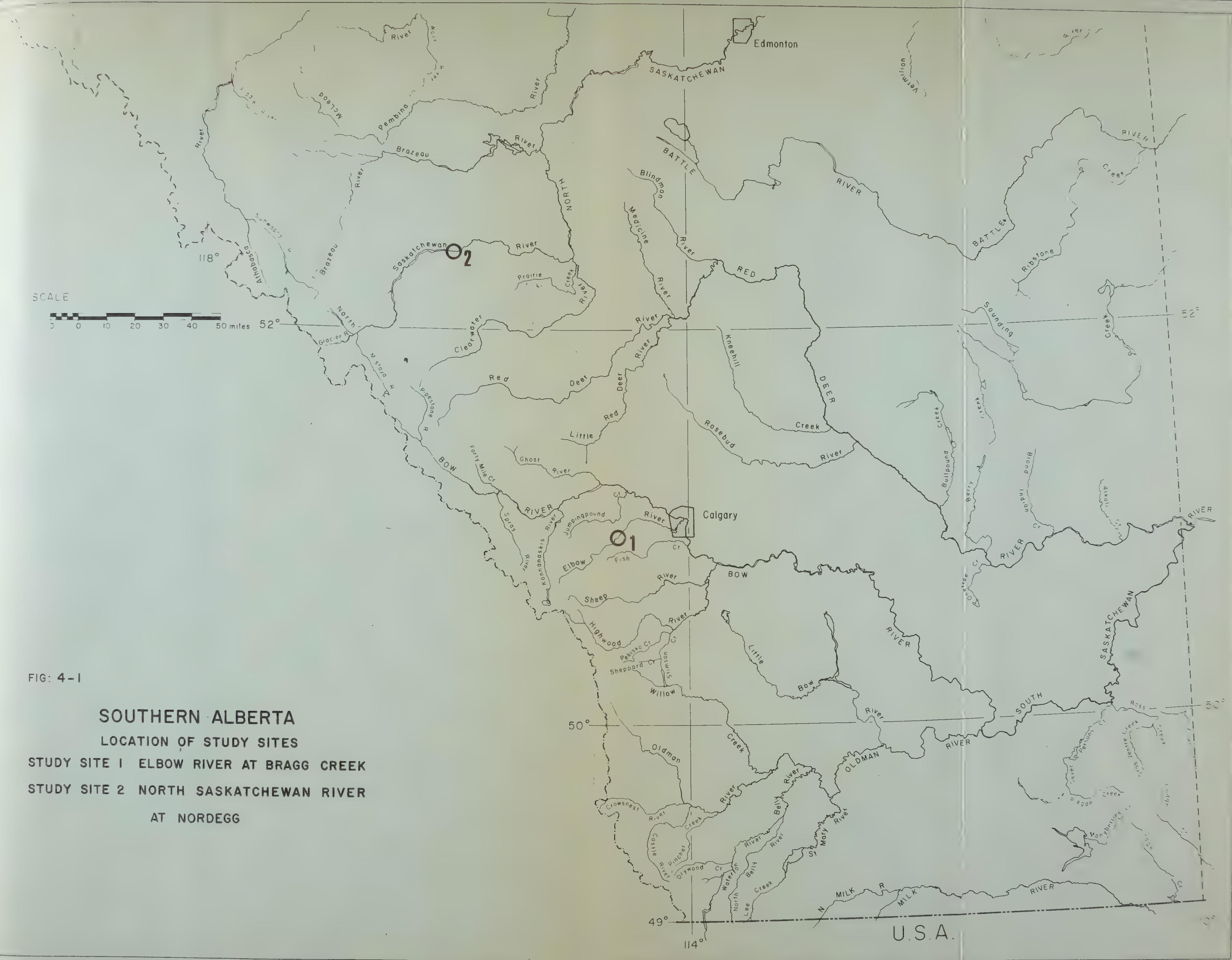


FIG: 4-1

SOUTHERN ALBERTA

LOCATION OF STUDY SITES

STUDY SITE 1 ELBOW RIVER AT BRAGG CREEK

STUDY SITE 2 NORTH SASKATCHEWAN RIVER AT NORDEGG

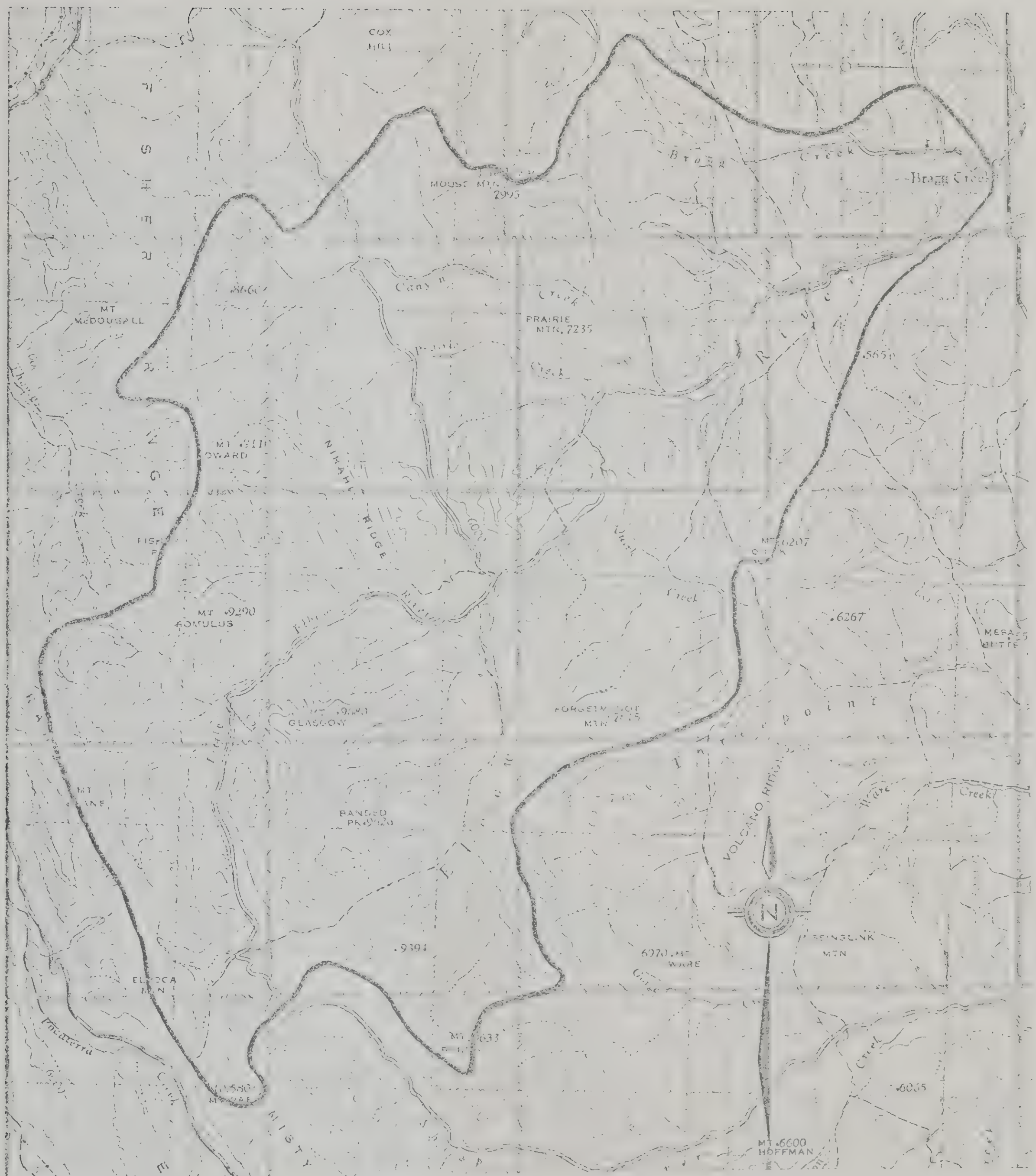


FIG. 4-2

Topographic map of Elbow River Basin
upstream of Bragg Creek
Scale: 1:250,000

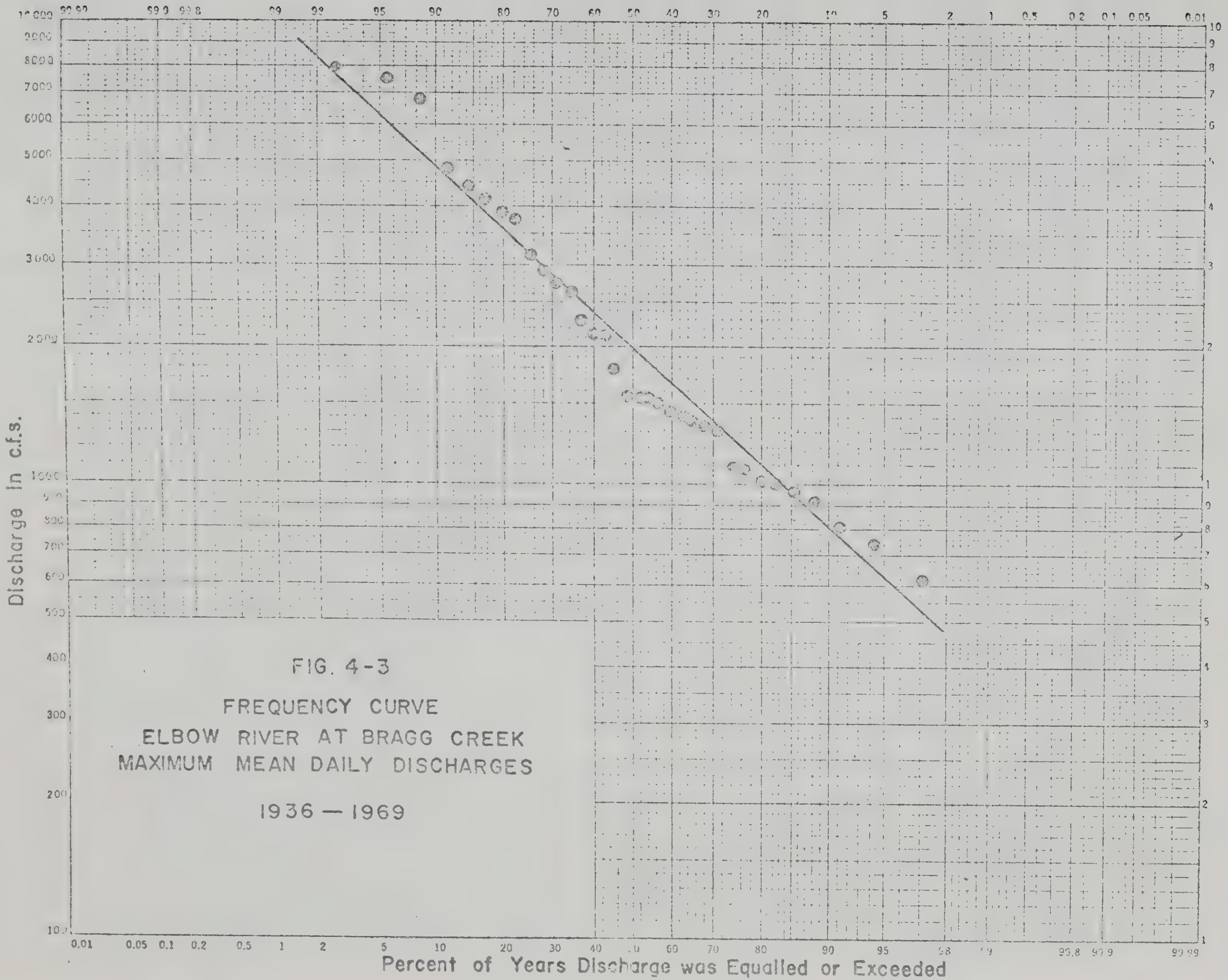
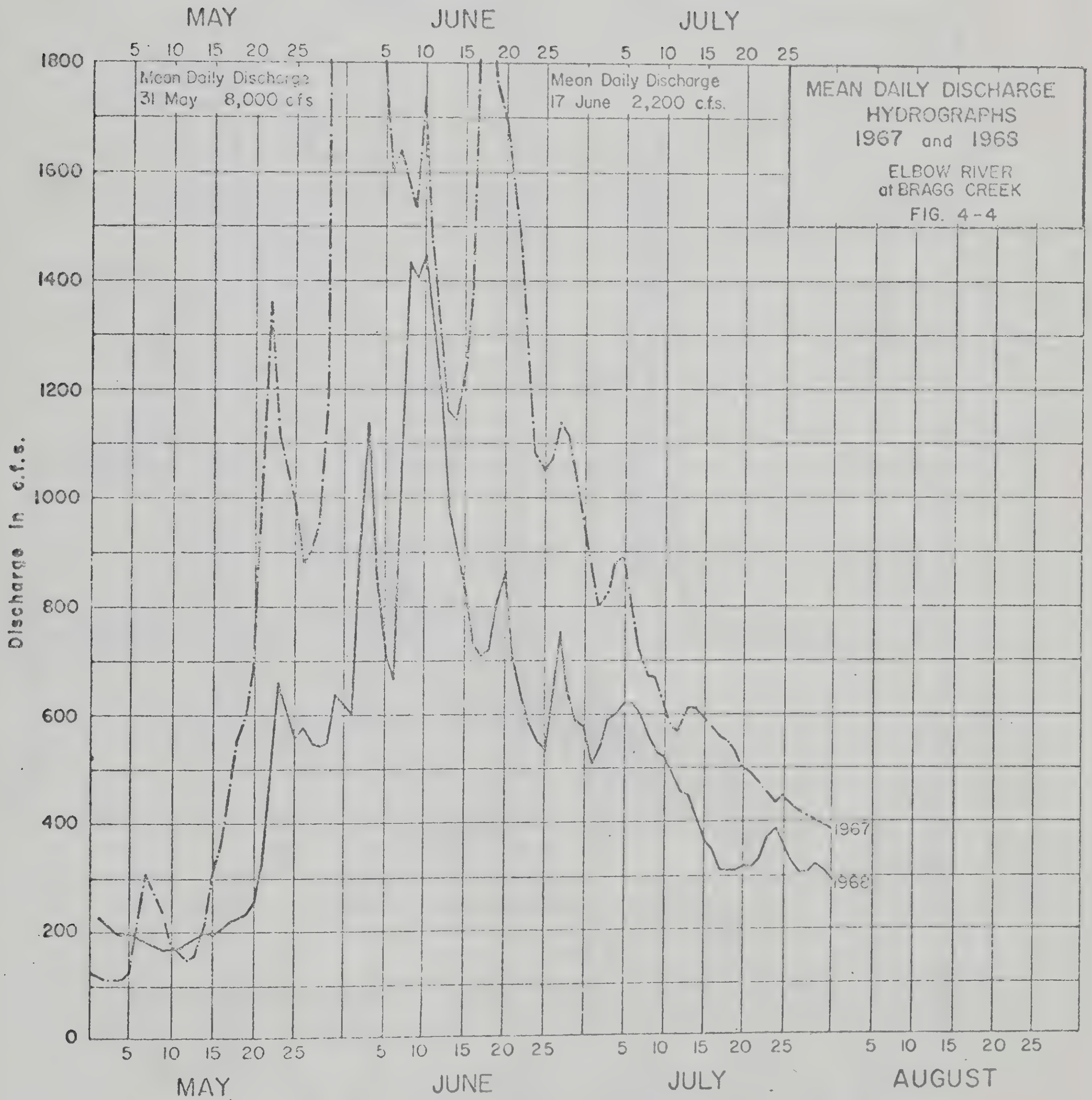


FIG. 4-3

FREQUENCY CURVE
ELBOW RIVER AT BRAGG CREEK
MAXIMUM MEAN DAILY DISCHARGES

1936 — 1969

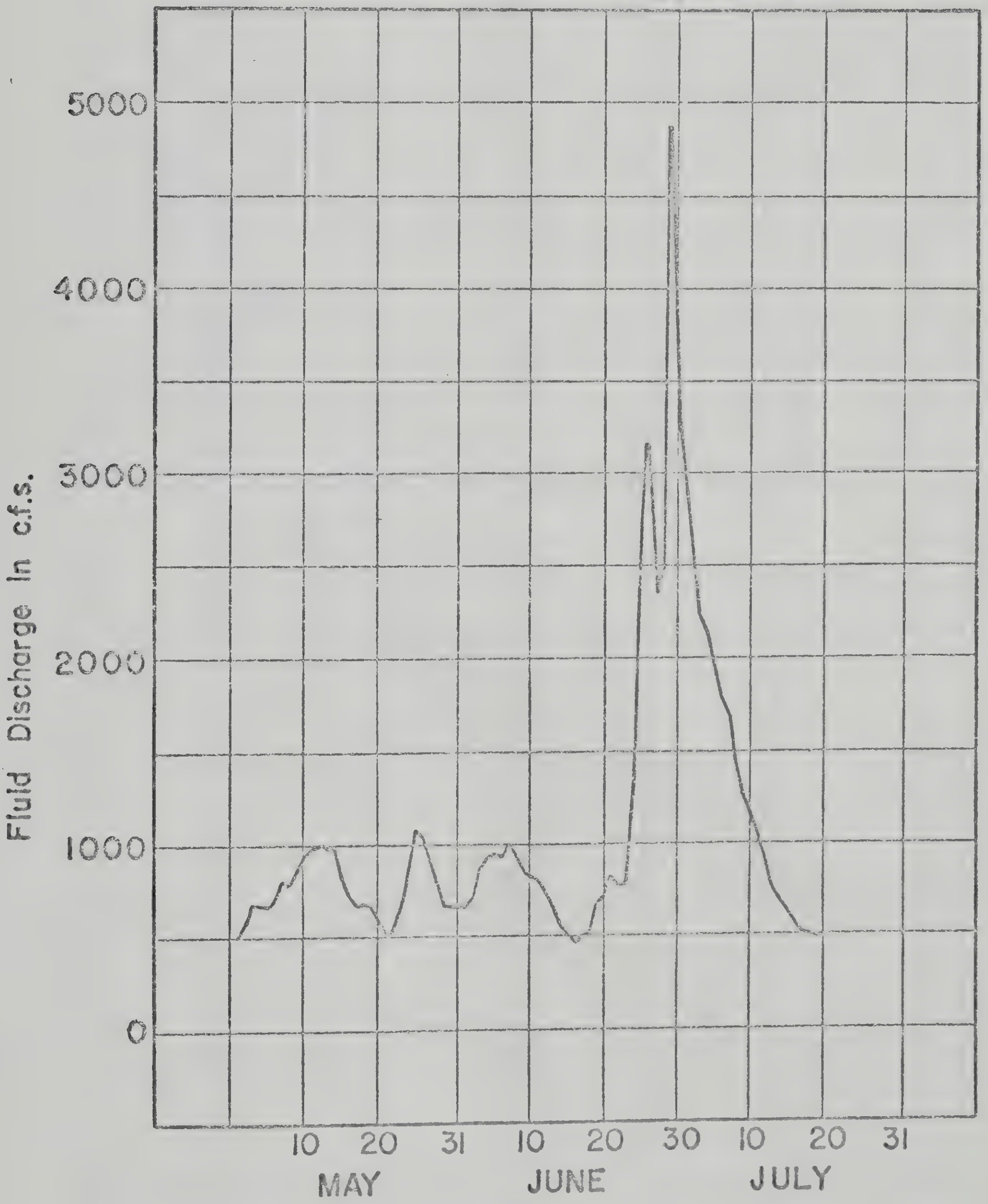


MEAN DAILY DISCHARGE
HYDROGRAPHS
1967 and 1968
ELBOW RIVER
at BRAGG CREEK
FIG. 4-4
Mean Daily Discharge
31 May 8,000 cfs
Mean Daily Discharge
17 June 2,200 c.f.s.
MAY
JUNE
JULY
AUGUST
Discharge in c.f.s.
1967
1968

FIG. 4-5

MEAN DAILY DISCHARGE
HYDROGRAPHS
1969

Elbow River at Bragg Creek



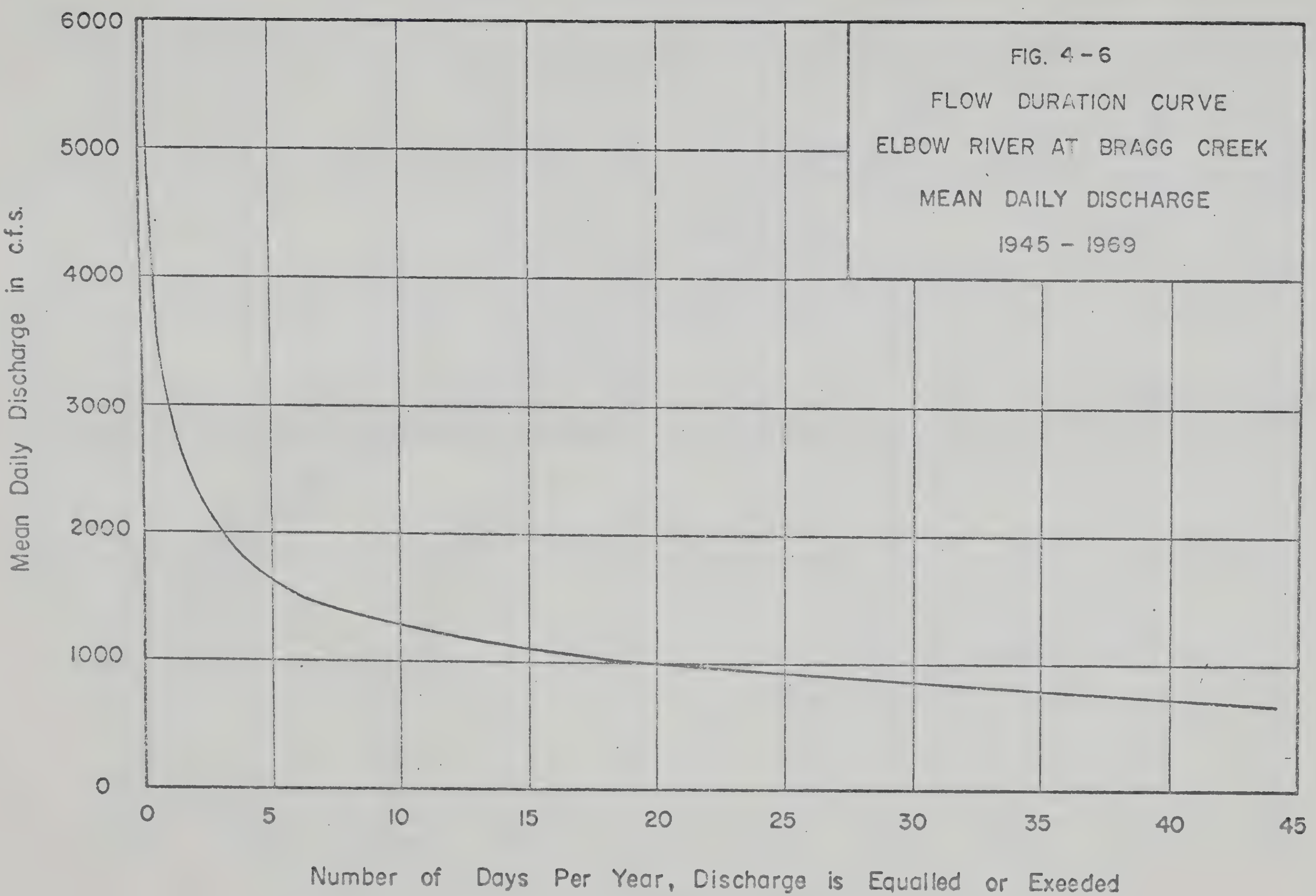


FIG. 4-6
FLOW DURATION CURVE
ELBOW RIVER AT BRAGG CREEK
MEAN DAILY DISCHARGE
1945 - 1969
Mean Daily Discharge in c.f.s.
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
40
45
Number of Days Per Year, Discharge is Equalled or Exeeded

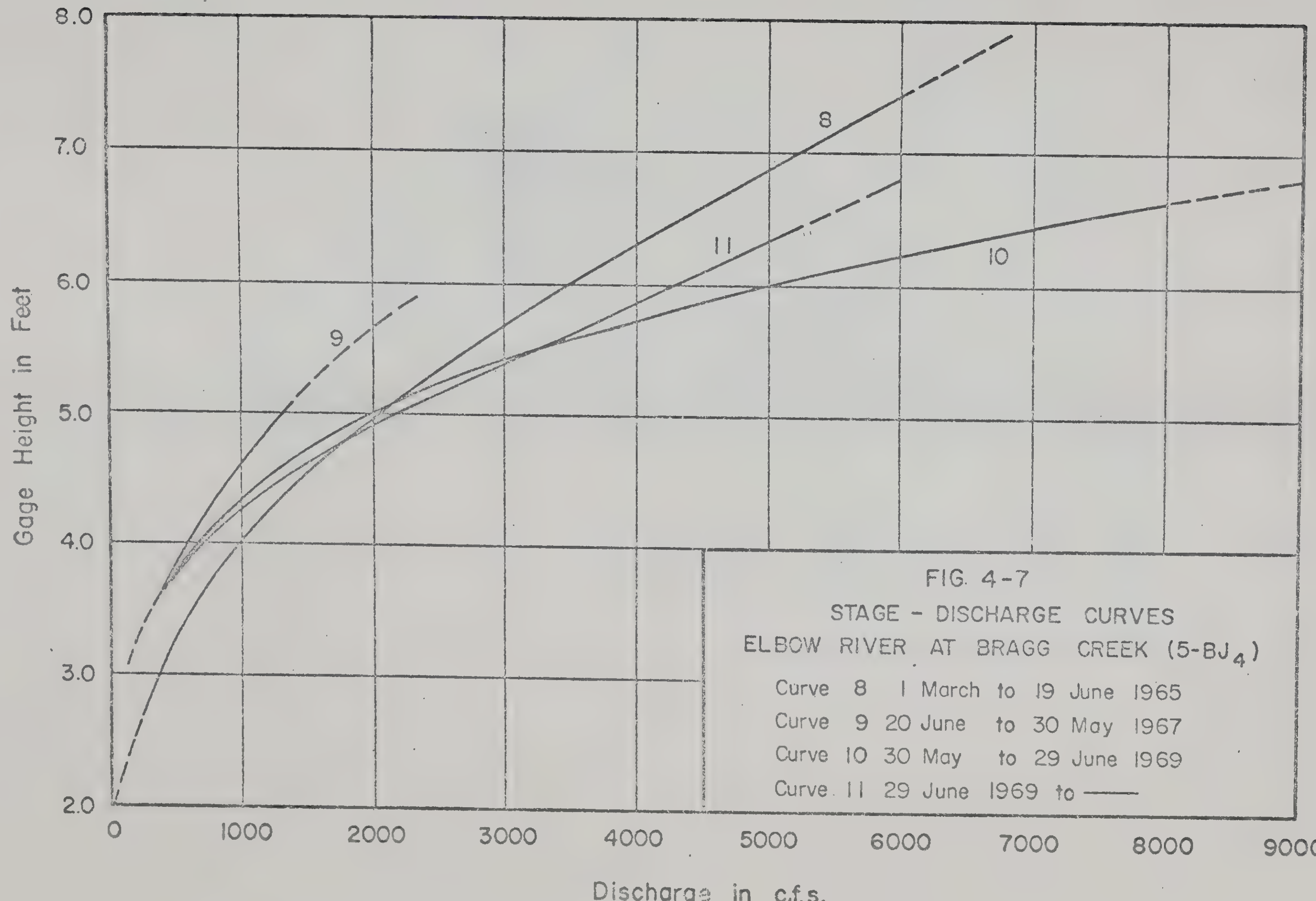


FIG. 4-7

STAGE - DISCHARGE CURVES

ELBOW RIVER AT BRAGG CREEK ($5\text{-}BJ_4$)

Curve 8 1 March to 19 June 1965
Curve 9 20 June to 30 May 1967
Curve 10 30 May to 29 June 1969
Curve 11 29 June 1969 to ——

Insert
Foldout
Here

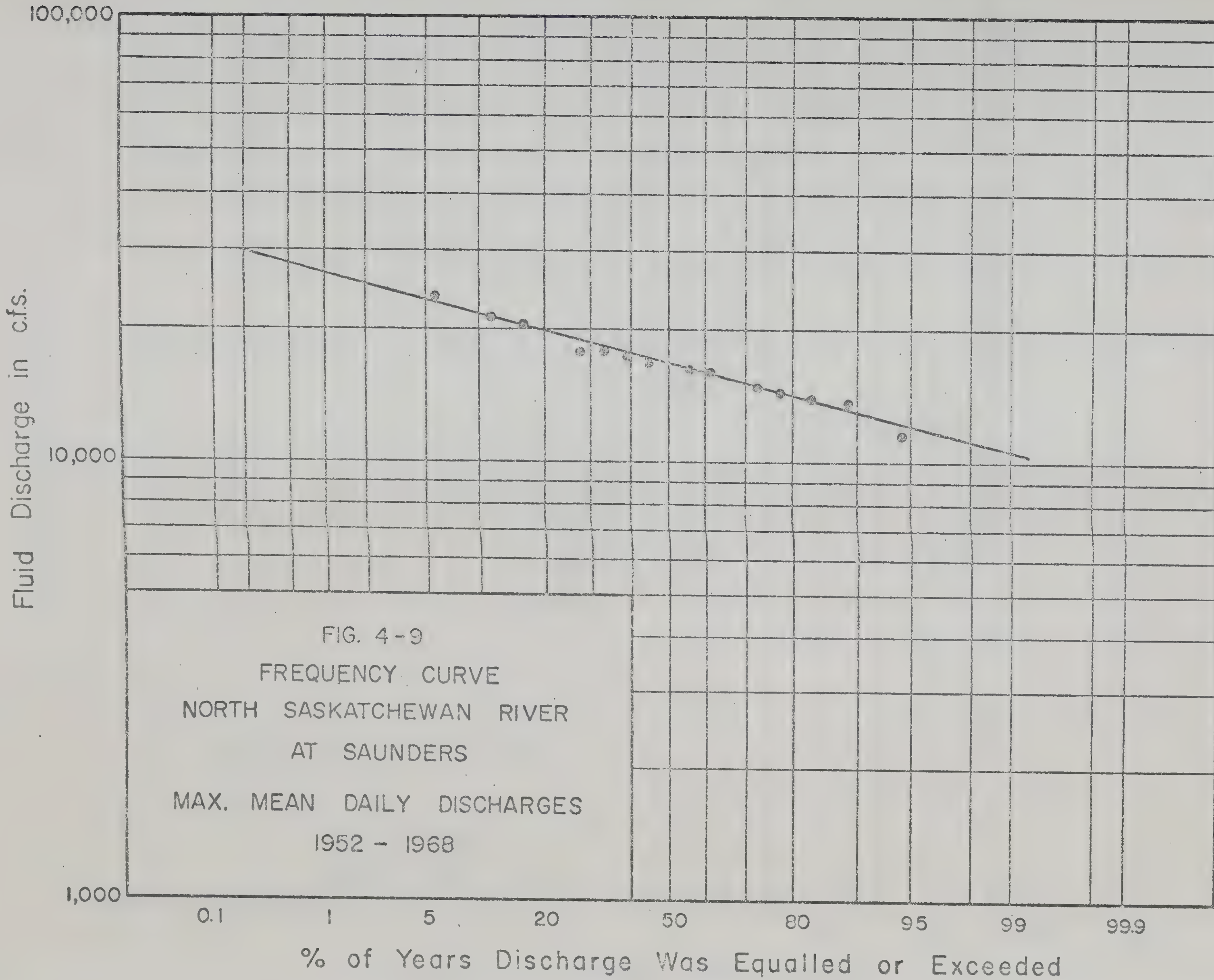


FIG. 4-9
FREQUENCY CURVE
NORTH SASKATCHEWAN RIVER
AT SAUNDERS

MAX. MEAN DAILY DISCHARGES
1952 - 1968

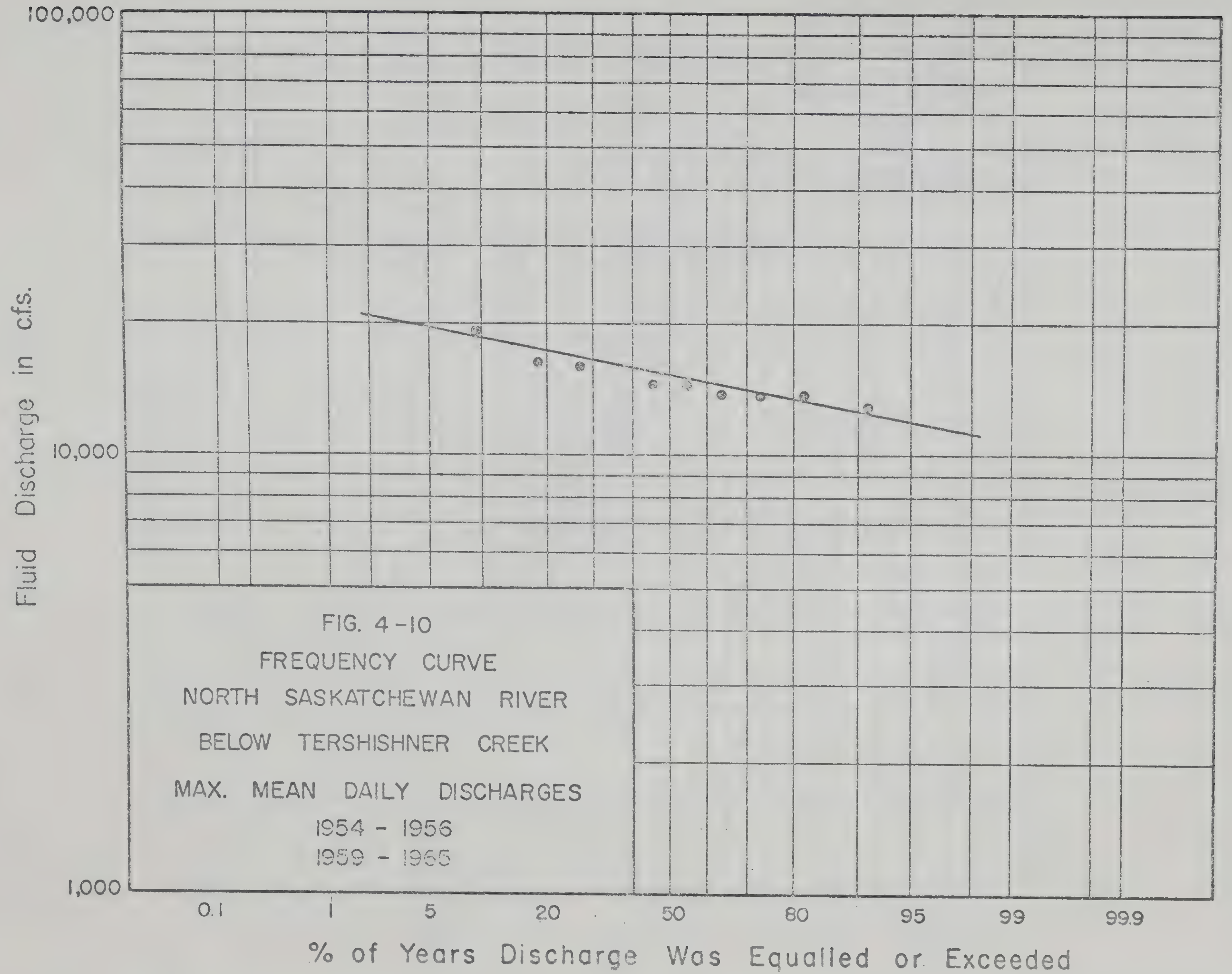


FIG. 4-10
FREQUENCY CURVE
NORTH SASKATCHEWAN RIVER
BELOW TERSHISHNER CREEK
MAX. MEAN DAILY DISCHARGES
1954 - 1956
1959 - 1965
100,000
10,000
1,000
Fluid Discharge in c.f.s.
0.1
1
5
20
50
80
95
99
99.9
% of Years Discharge Was Equalled or Exceeded

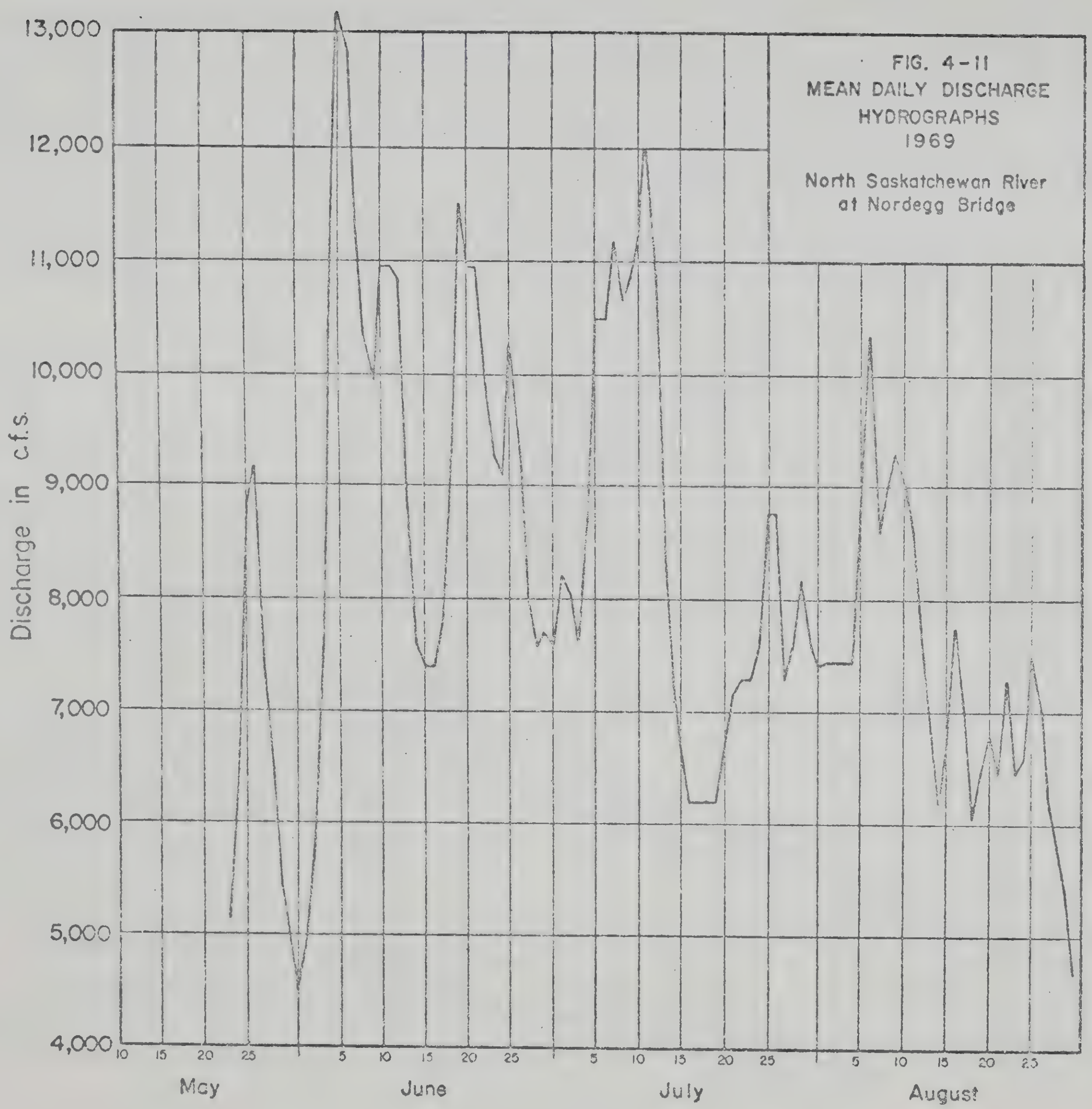


FIG. 4-11
MEAN DAILY DISCHARGE
HYDROGRAPHS
1969
North Saskatchewan River
at Nordegg Bridge
Discharge in c.f.s.
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
10
15
20
25
5
10
15
20
25
5
10
15
20
25
5
10
15
20
25
May
June
July
August

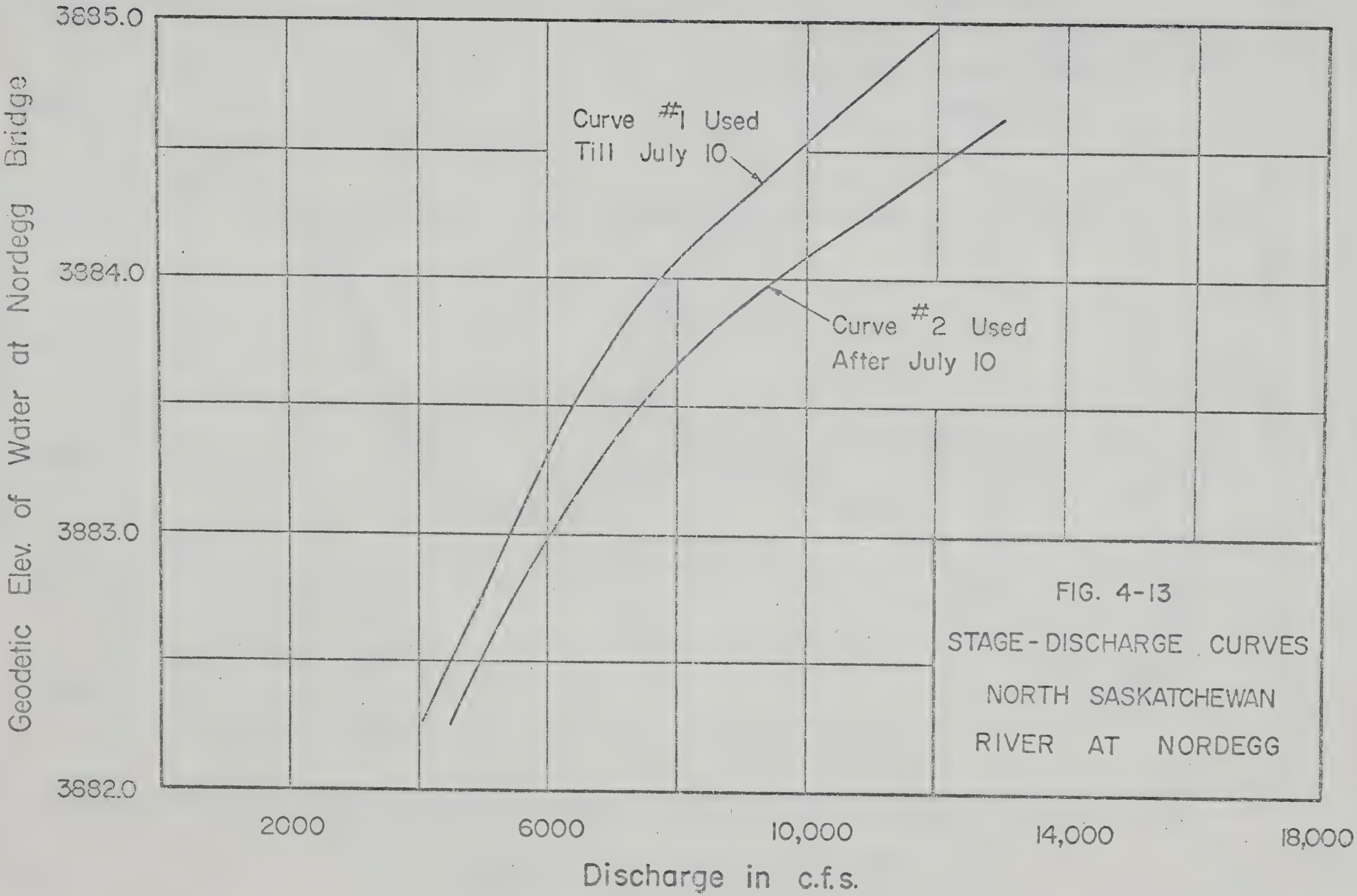


FIG. 4-13

STAGE-DISCHARGE CURVES

NORTH SASKATCHEWAN

RIVER AT NORDEGG

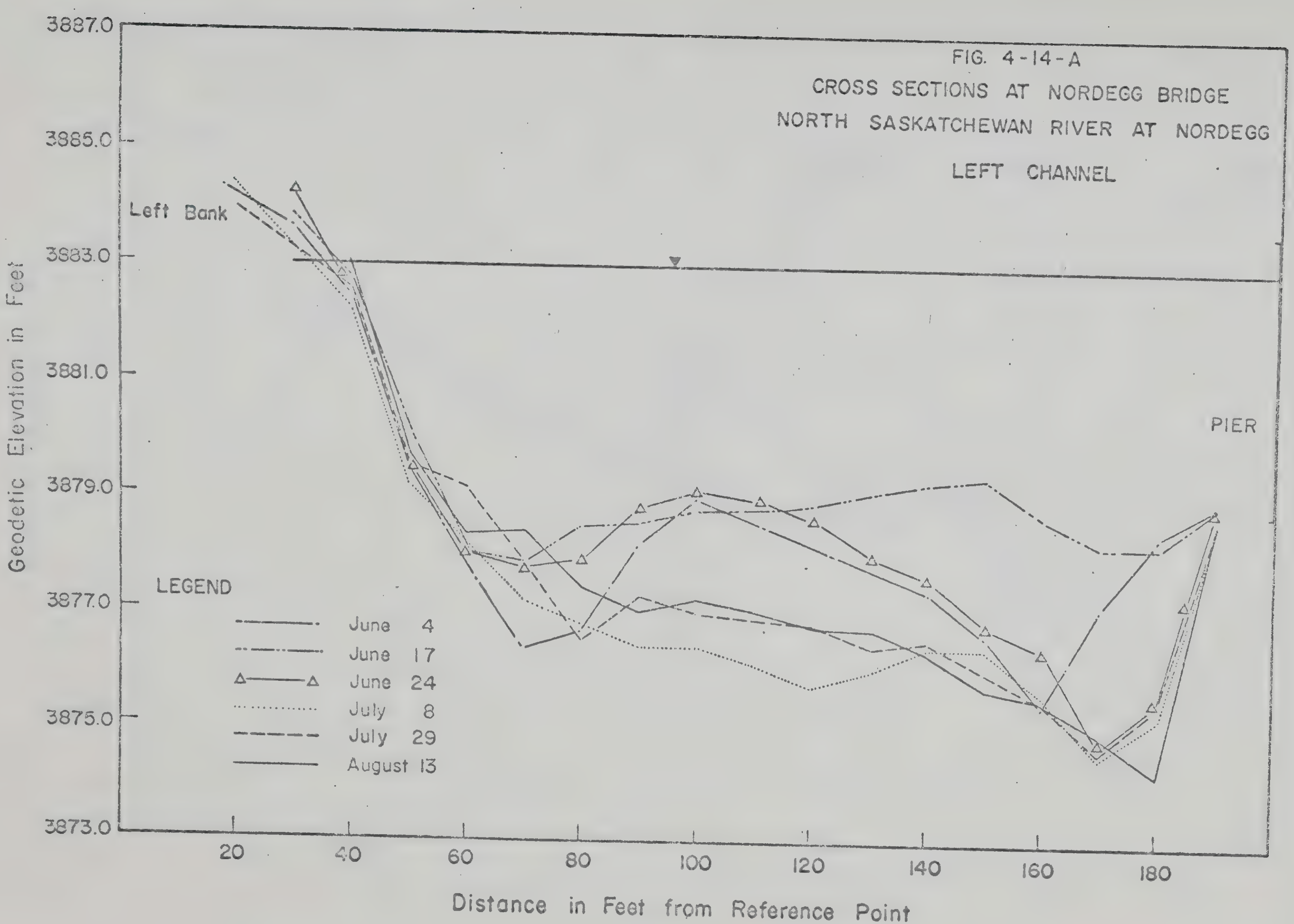


FIG. 4-14-A
CROSS SECTIONS AT NORDEGG BRIDGE
NORTH SASKATCHEWAN RIVER AT NORDEGG
LEFT CHANNEL
Left Bank
PIER
LEGEND
June 4
June 17
June 24
July 8
July 29
August 13
Geodetic Elevation in Feet
3887.0
3885.0
3883.0
3881.0
3879.0
3877.0
3875.0
3873.0
Distance in Feet from Reference Point
20
40
60
80
100
120
140
160
180

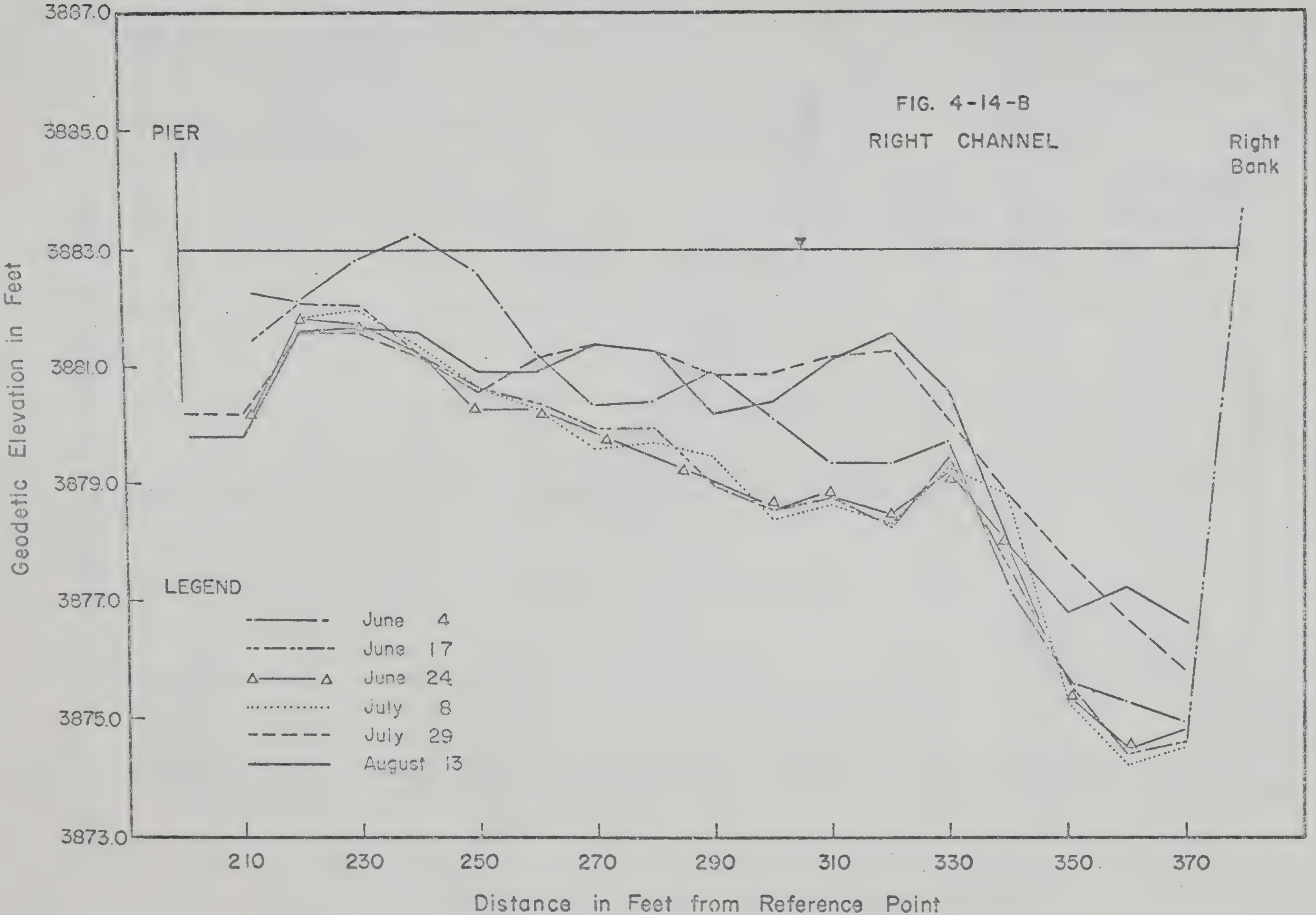


FIG. 4-14-B
RIGHT CHANNEL
PIER
Right Bank
LEGEND
June 4
June 17
June 24
July 8
July 29
August 13
Geodetic Elevation in Feet
3887.0
3885.0
3883.0
3881.0
3879.0
3877.0
3875.0
3873.0
210
230
250
270
290
310
330
350
370
Distance in Feet from Reference Point

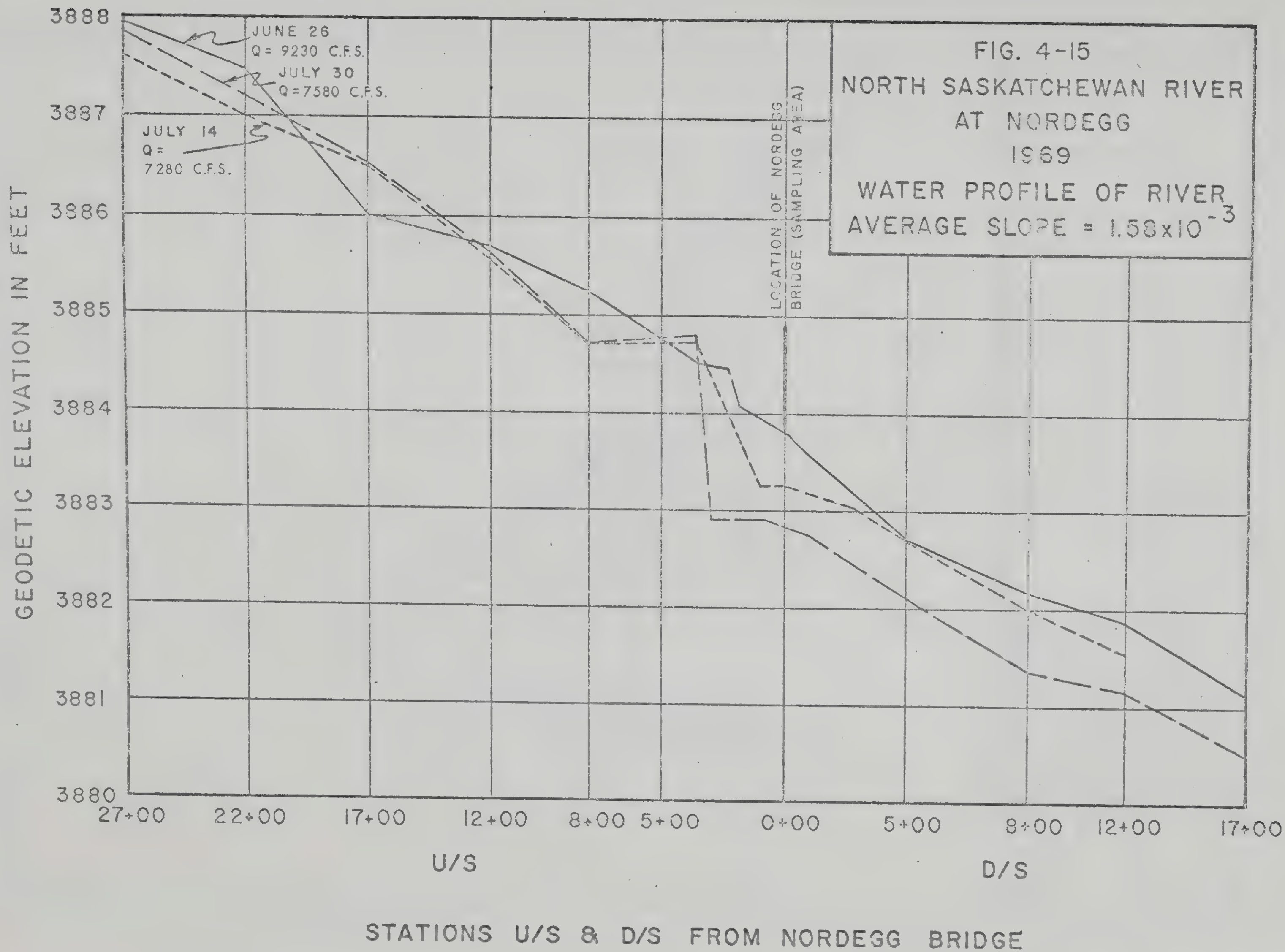


FIG. 4-15
NORTH SASKATCHEWAN RIVER
AT NORDEGG
1969
WATER PROFILE OF RIVER
AVERAGE SLOPE = 1.58x10^-3
JUNE 26
Q= 9230 C.F.S.
JULY 30
Q=7580 C.F.S.
JULY 14
Q=
7280 C.F.S.
LOCATION OF NORDEGG
BRIDGE (SAMPLING AREA)
GEODETIC ELEVATION IN FEET
3888
3887
3886
3885
3884
3883
3882
3881
3880
27+00
22+00
17+00
12+00
8+00
5+00
0+00
5+00
8+00
12+00
17+00
U/S
D/S
STATIONS U/S & D/S FROM NORDEGG BRIDGE

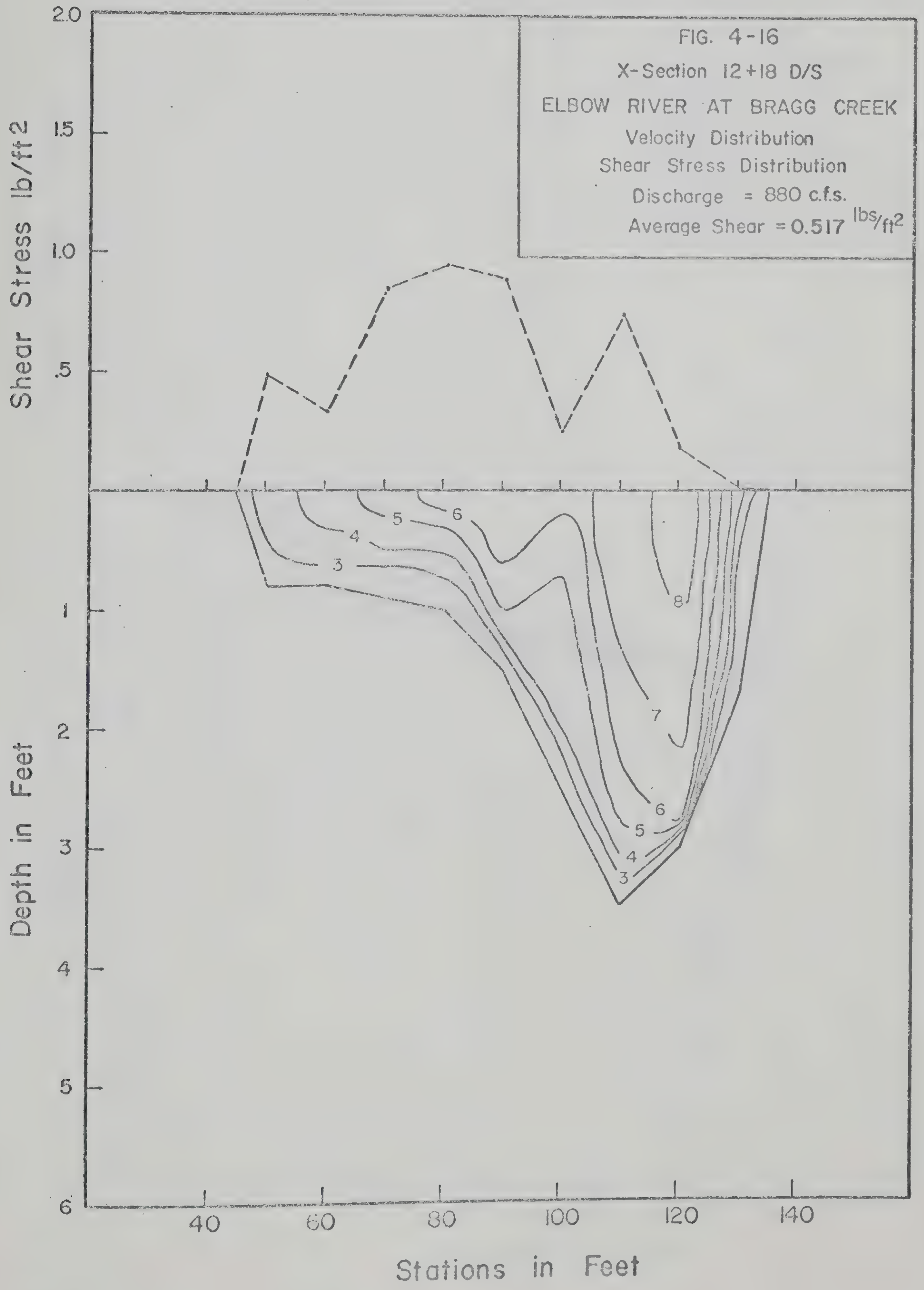


FIG. 4-16
X-Section 12+18 D/S
ELBOW RIVER AT BRAGG CREEK
Velocity Distribution
Shear Stress Distribution
Discharge = 880 c.f.s.
Average Shear = 0.517 lbs/ft2
Shear Stress lb/ft2
Depth in Feet
Stations in Feet
2.0
1.5
1.0
.5
1
2
3
4
5
6
40
60
80
100
120
140
3
4
5
6
7
8

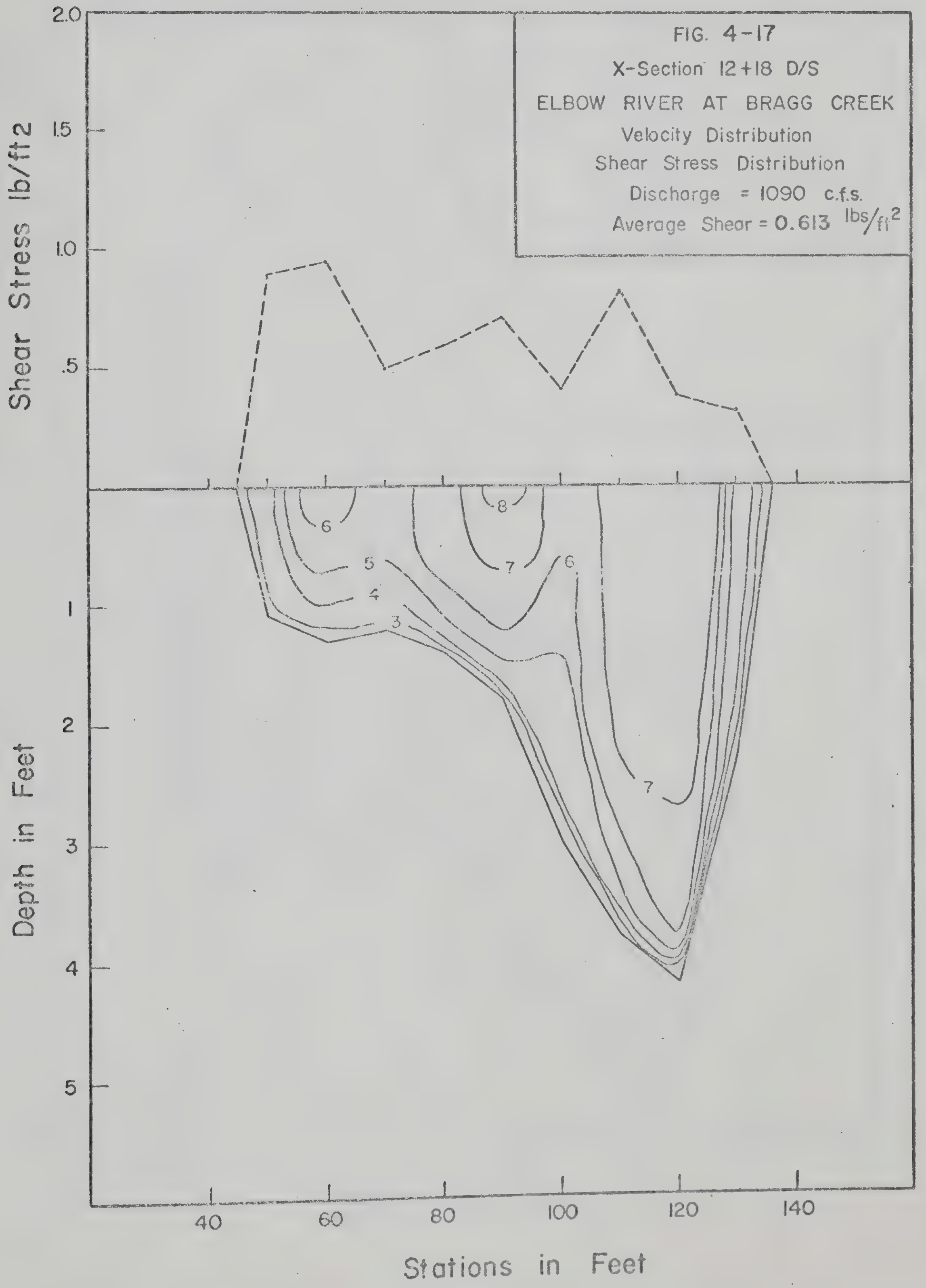
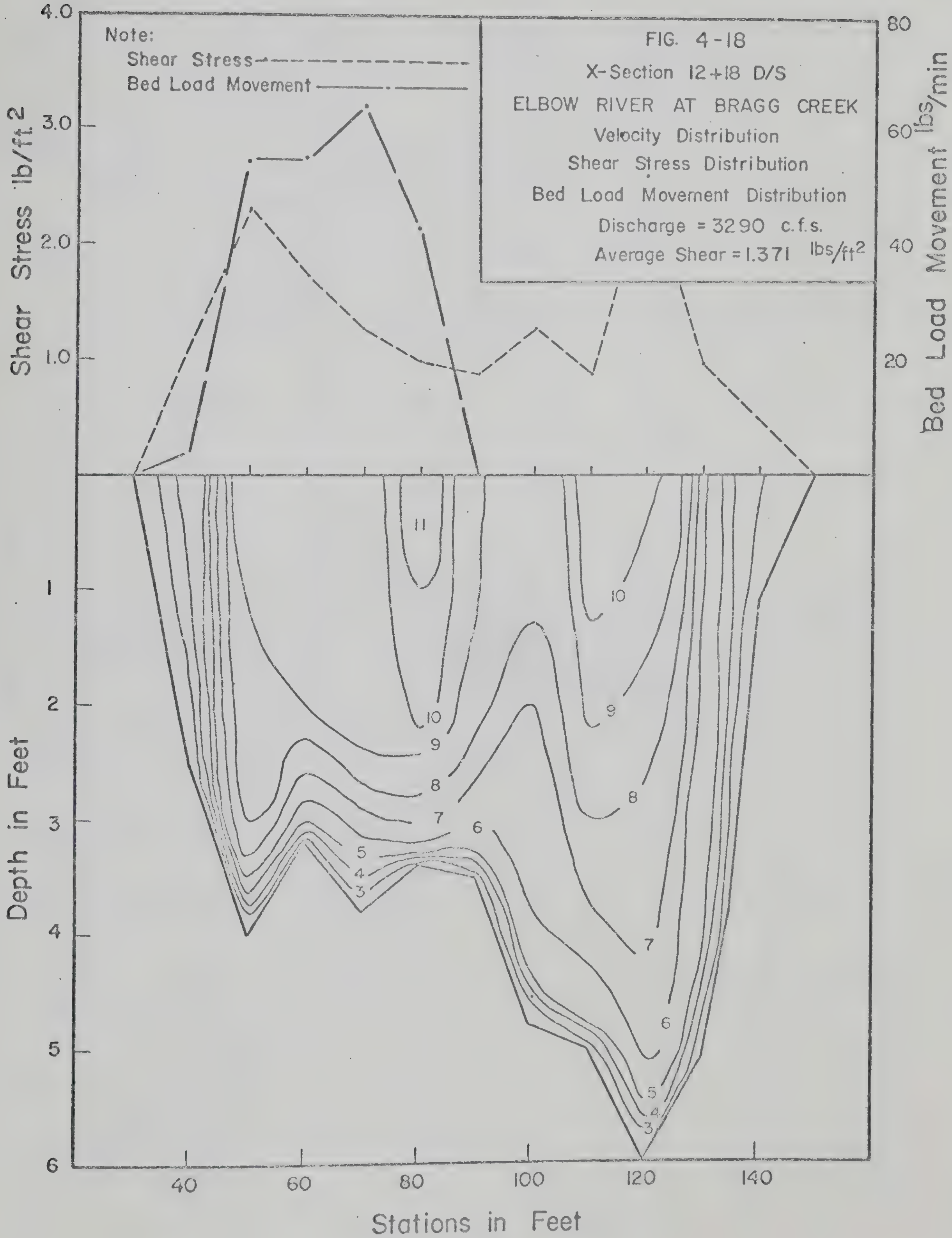


FIG. 4-17
X-Section 12+18 D/S
ELBOW RIVER AT BRAGG CREEK
Velocity Distribution
Shear Stress Distribution
Discharge = 1090 c.f.s.
Average Shear = 0.613 lbs/ft^2



Note:
Shear Stress
Bed Load Movement
FIG. 4-18
X-Section 12+18 D/S
ELBOW RIVER AT BRAGG CREEK
Velocity Distribution
Shear Stress Distribution
Bed Load Movement Distribution
Discharge = 3290 c.f.s.
Average Shear = 1.371 lbs/ft²
Shear Stress lb/ft²
Bed Load Movement lbs/min
Depth in Feet
Stations in Feet
4.0
3.0
2.0
1.0
80
60
40
20
1
2
3
4
5
6
40
60
80
100
120
140

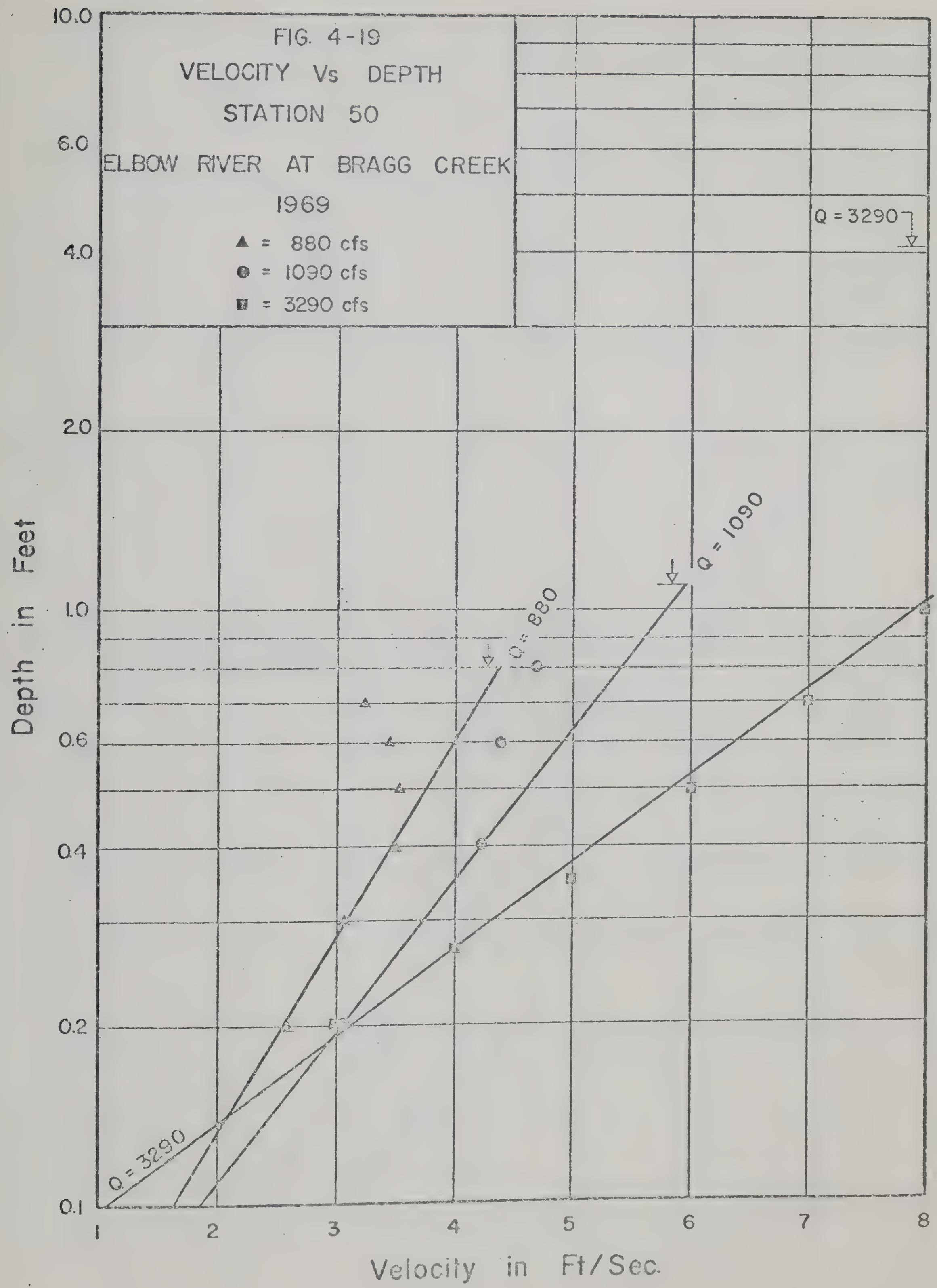


FIG. 4-19
VELOCITY Vs DEPTH
STATION 50
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Q = 1090
Q = 880
Q = 3290
Depth in Feet
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Velocity in Ft/Sec.

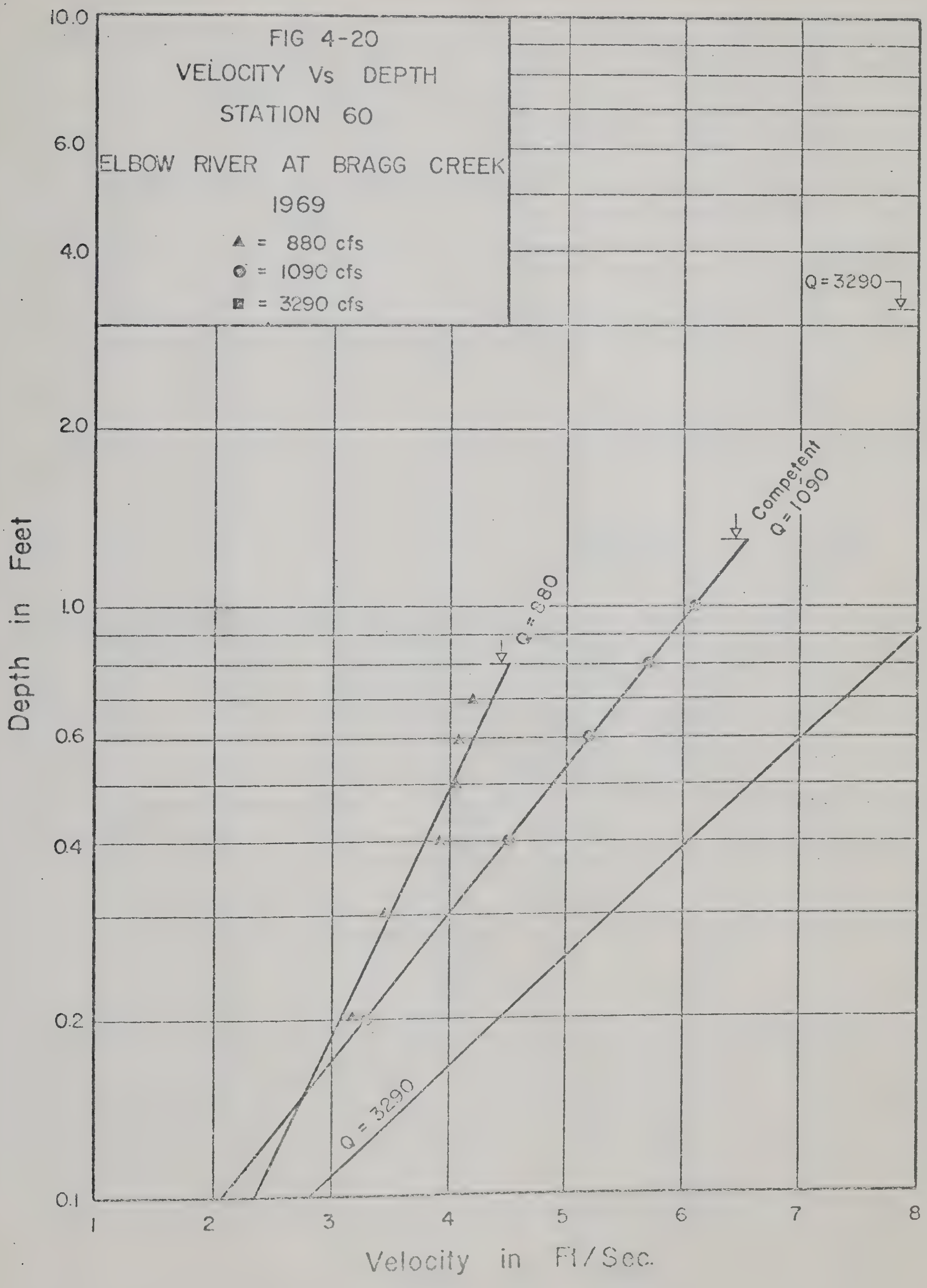


FIG 4-20
VELOCITY Vs DEPTH
STATION 60
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Competent
Q = 1090
Q = 880
Q = 3290
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Depth in Feet
Velocity in Ft/Sec.

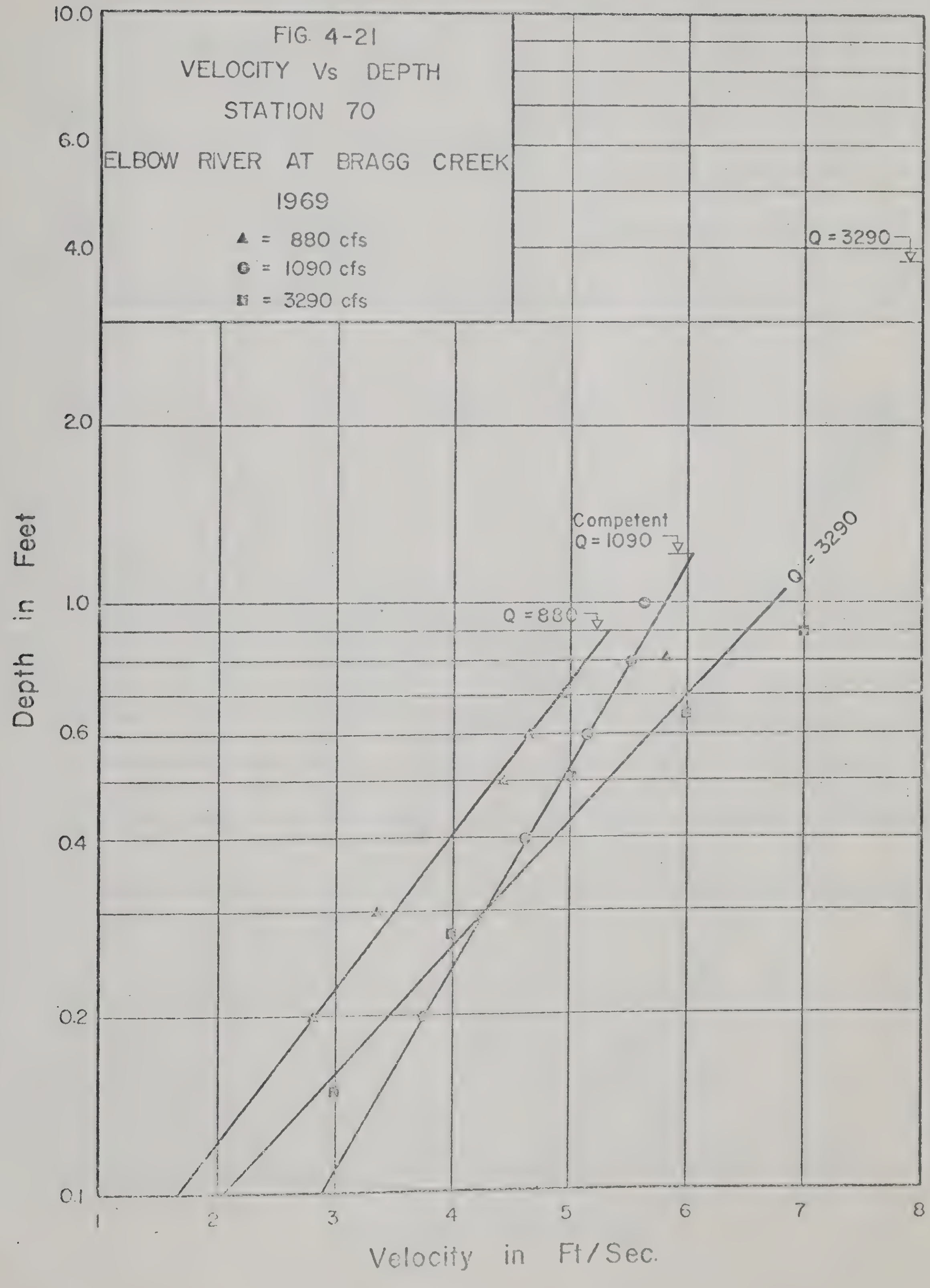


FIG. 4-21
VELOCITY Vs DEPTH
STATION 70
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Competent
Q = 1090
Q = 880
Q = 3290
Depth in Feet
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Velocity in Ft/Sec.

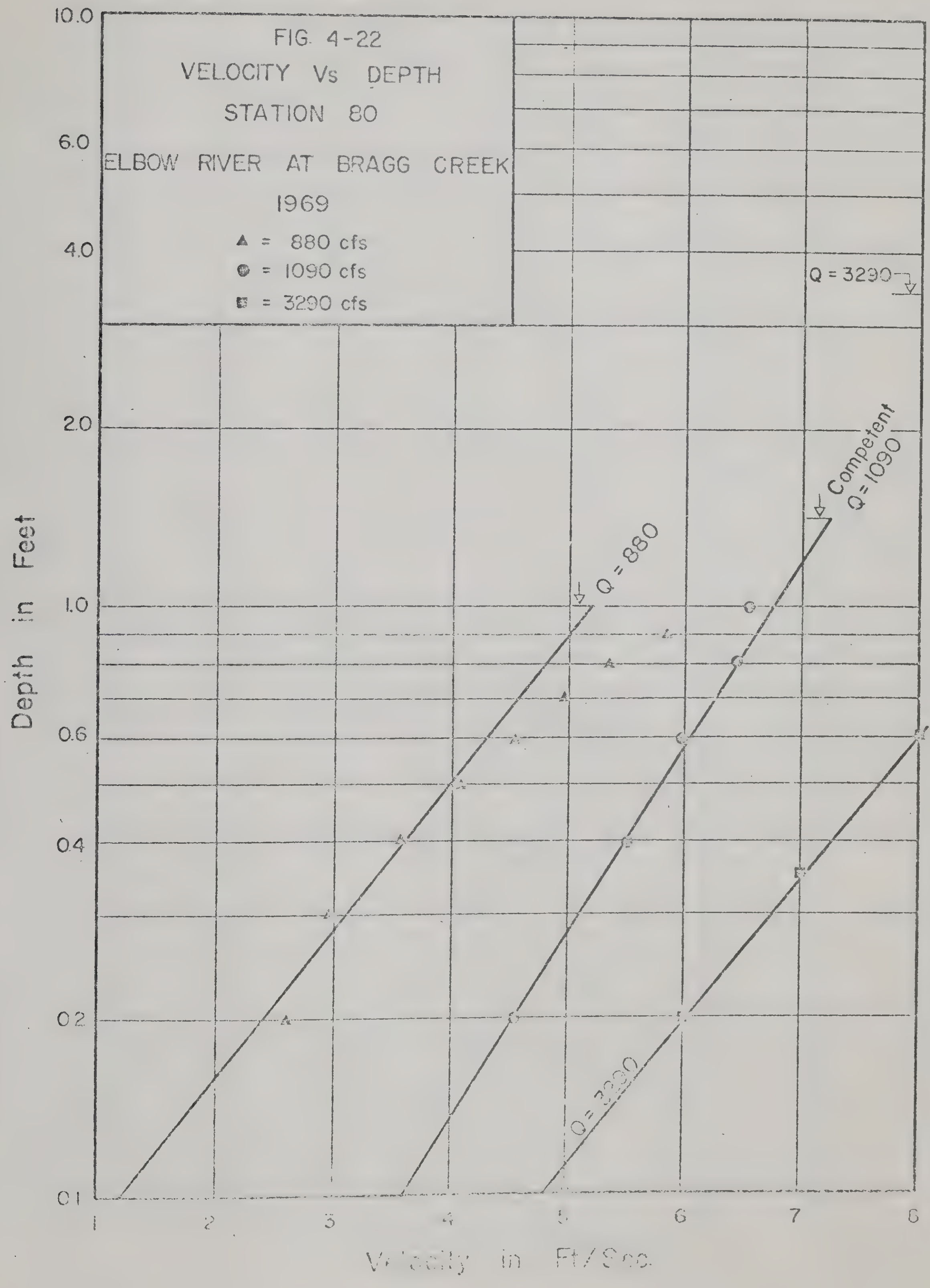


FIG. 4-22
VELOCITY Vs DEPTH
STATION 80
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Competent Q = 1090
Q = 880
Depth in Feet
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Velocity in Ft/Sec.

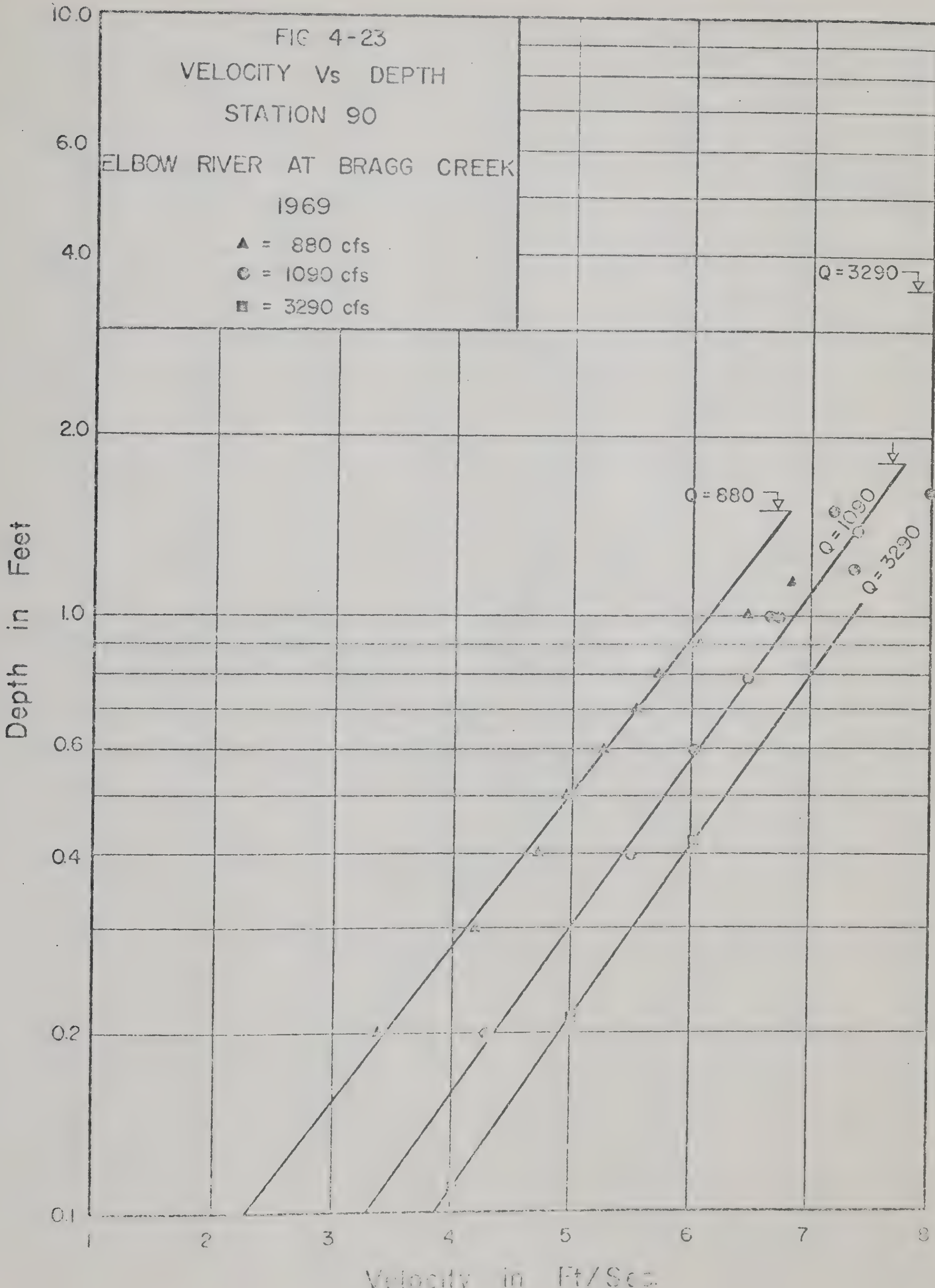


FIG 4-23
VELOCITY Vs DEPTH
STATION 90
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Q = 880
Q = 1090
Q = 3290
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Depth in Feet
Velocity in Ft/Sec

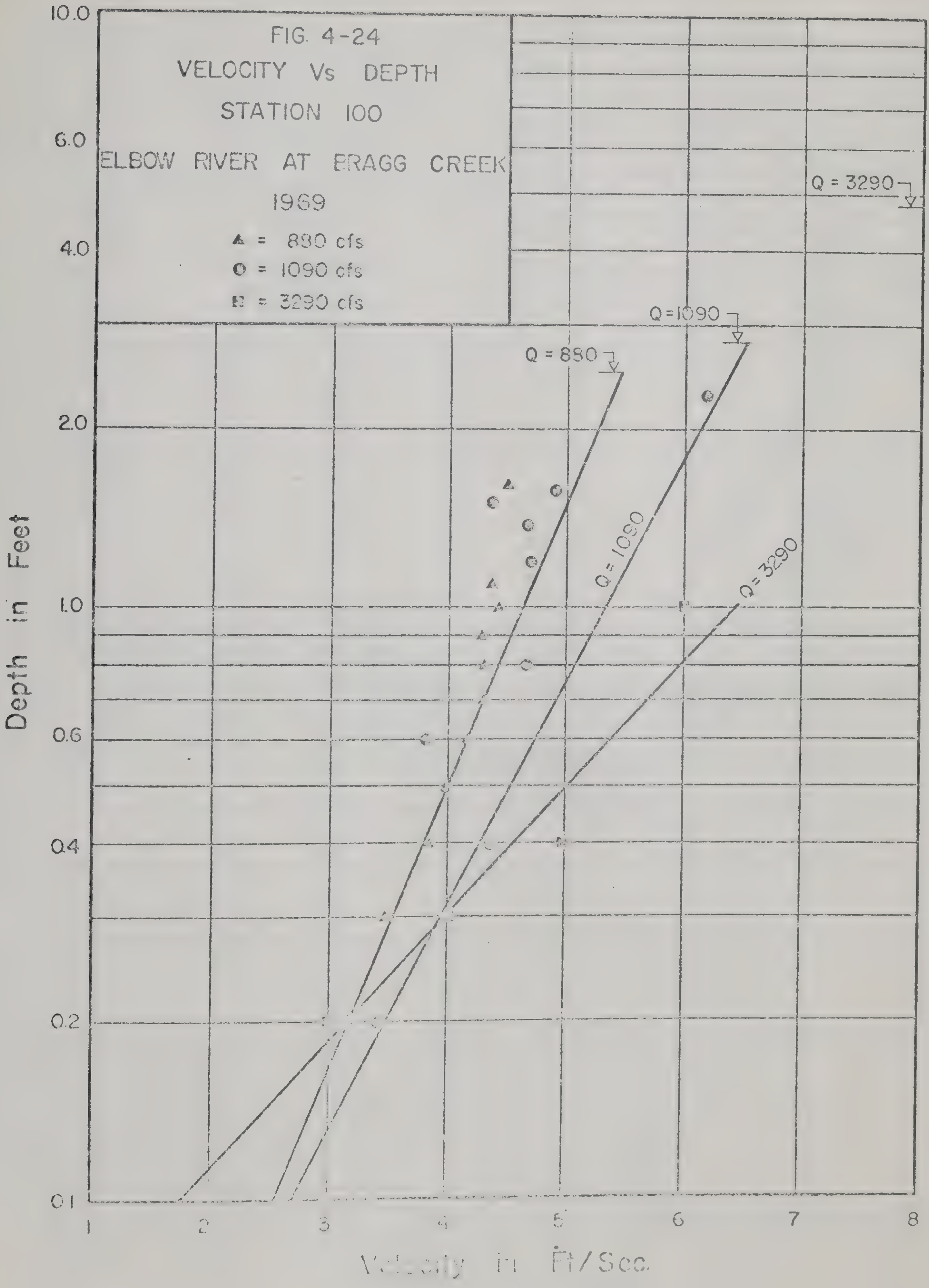


FIG. 4-24
VELOCITY Vs DEPTH
STATION 100
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Q=1090
Q = 880
Q = 1090
Q = 3290
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
1
2
3
4
5
6
7
8
Depth in Feet
Velocity in Ft/Sec.

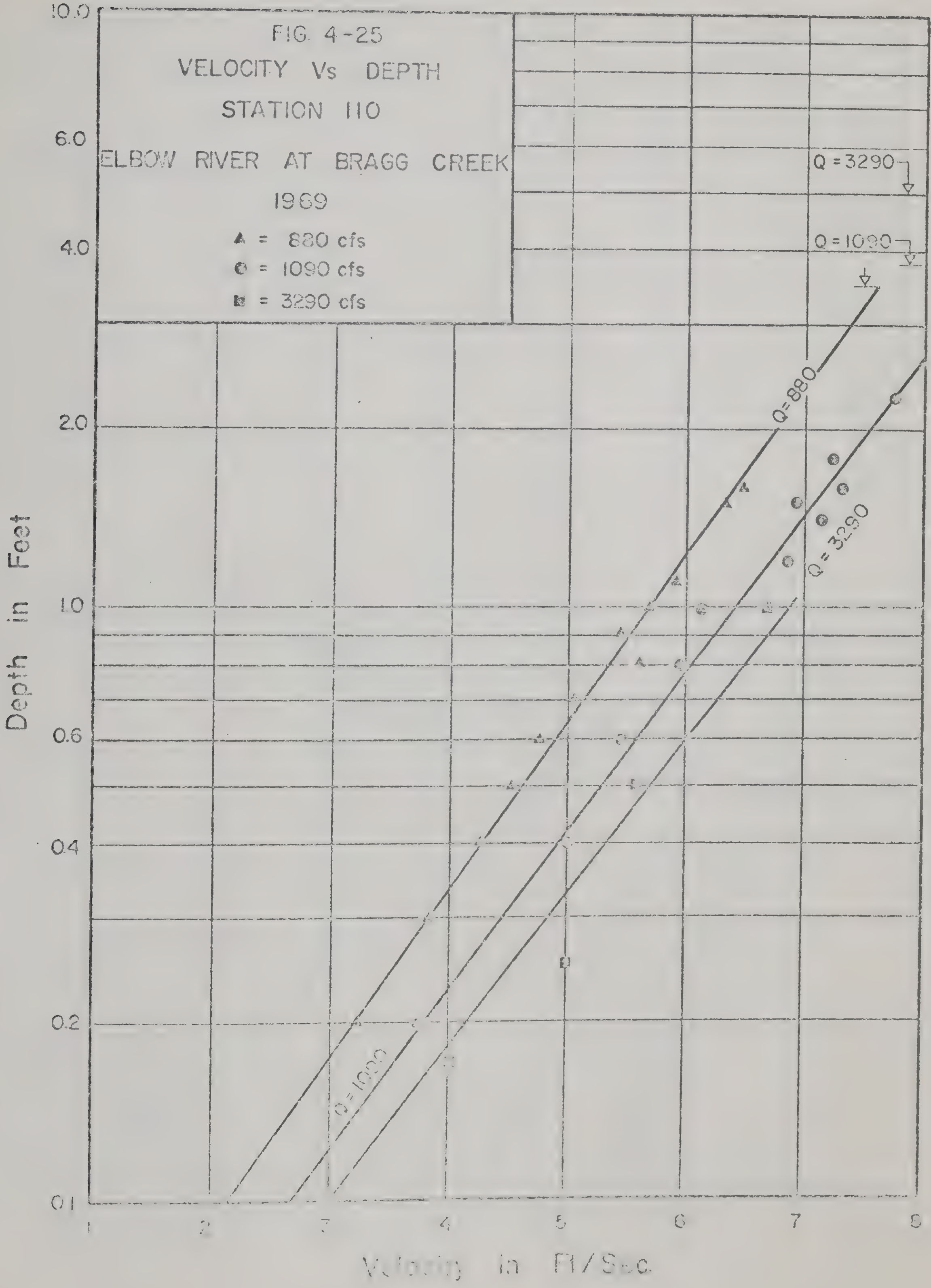


FIG. 4-25
VELOCITY Vs DEPTH
STATION 110
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Q = 1090
Q=880
Q=3290
Q=1090
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
Depth in Feet
1
2
3
4
5
6
7
8
Velocity in Ft/Sec.

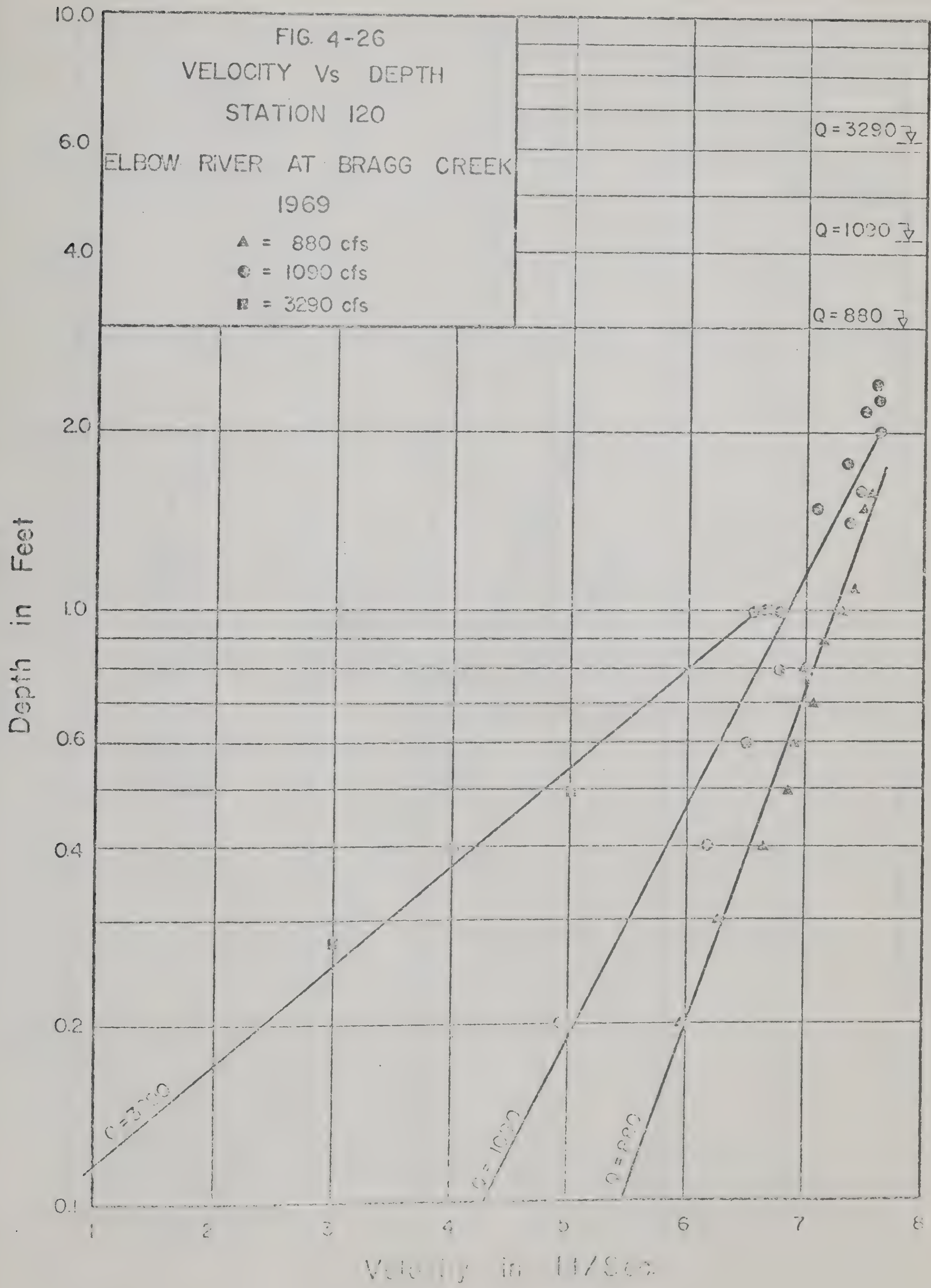


FIG. 4-26
VELOCITY Vs DEPTH
STATION 120
ELBOW RIVER AT BRAGG CREEK
1969

▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs

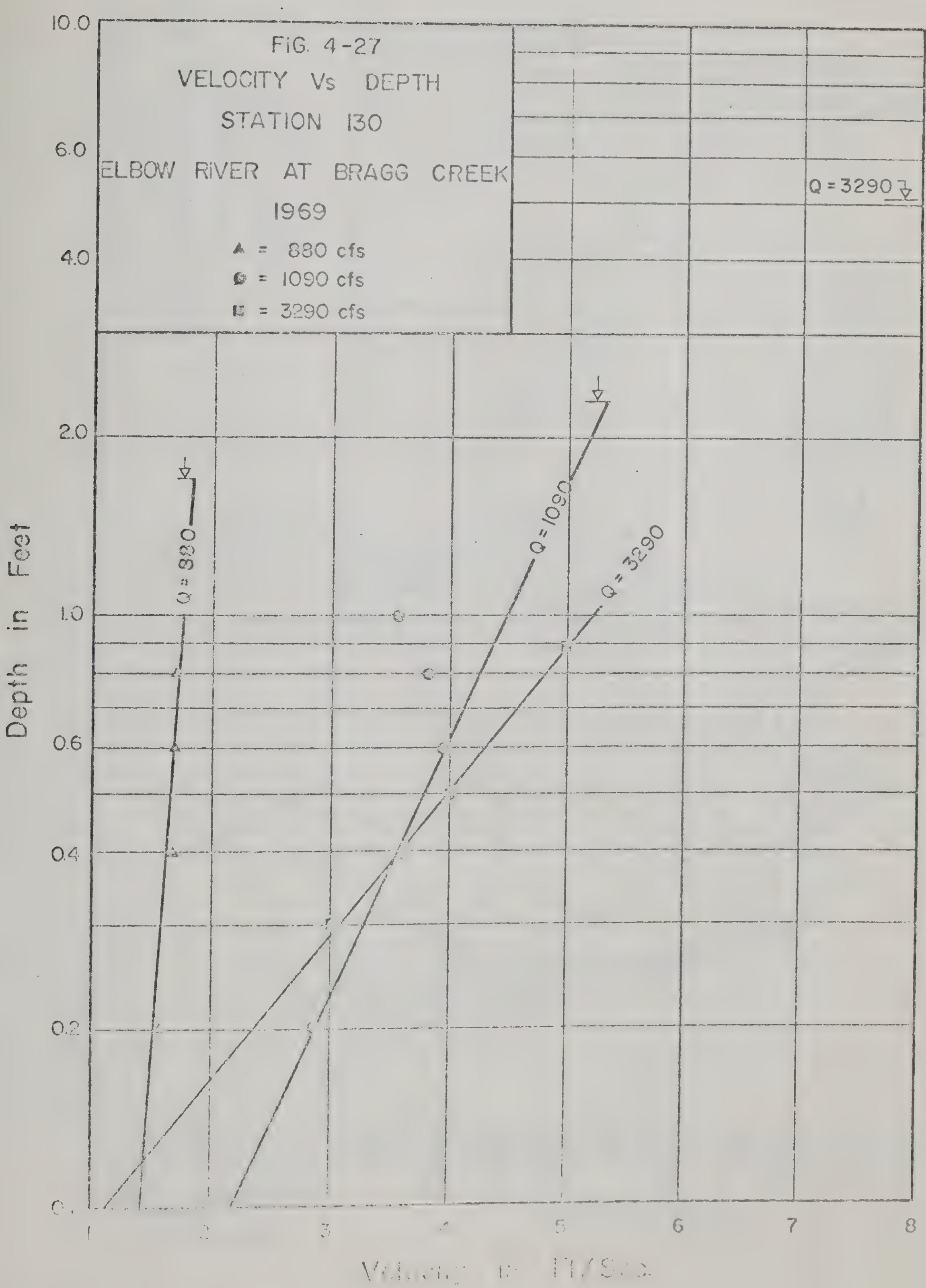


FIG. 4-27
VELOCITY Vs DEPTH
STATION 130
ELBOW RIVER AT BRAGG CREEK
1969
▲ = 880 cfs
● = 1090 cfs
■ = 3290 cfs
Q = 3290
Q = 880
Q = 1090
Q = 3290
Depth in Feet
10.0
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.
1
2
3
4
5
6
7
8

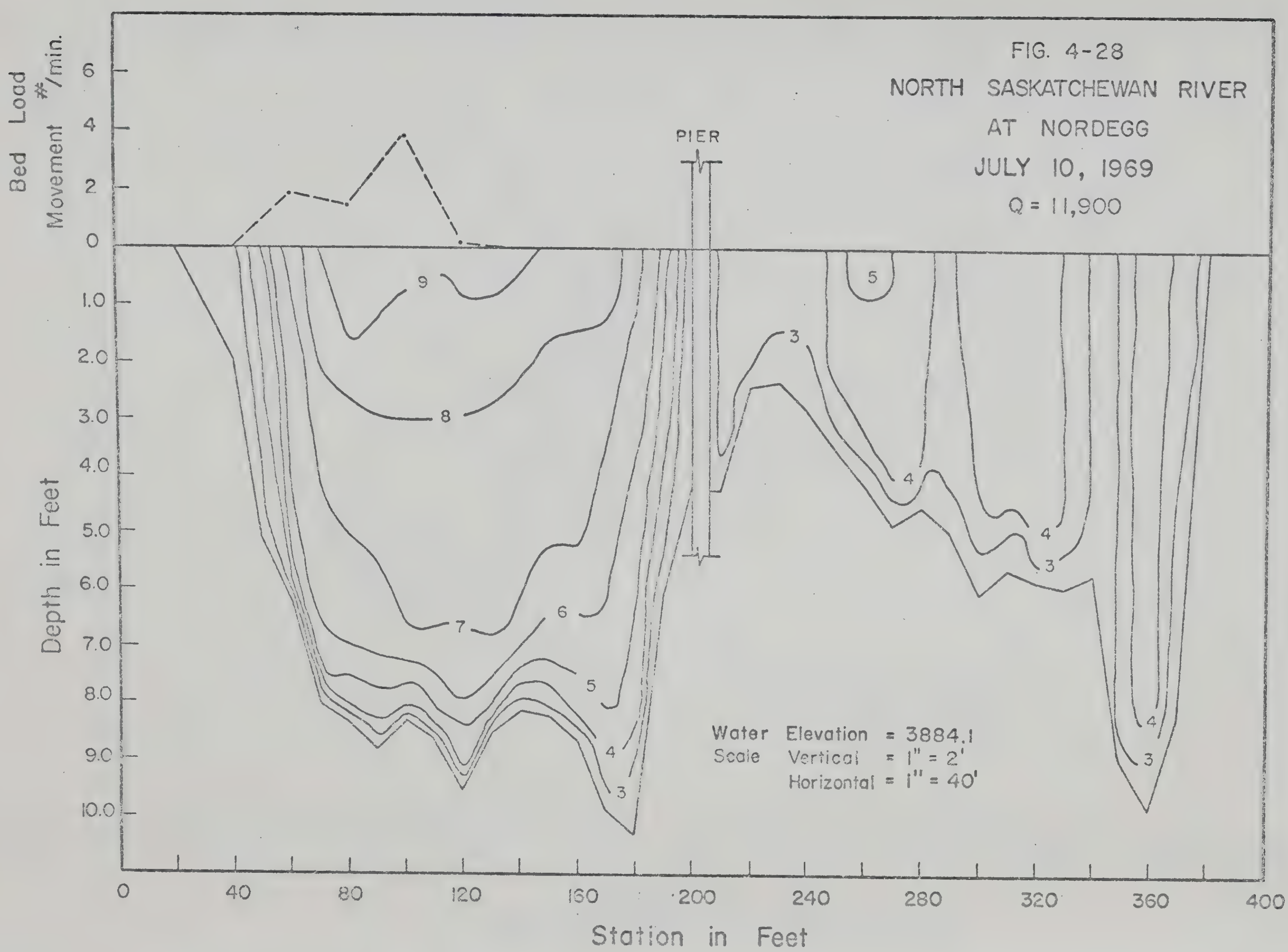


FIG. 4-28
NORTH SASKATCHEWAN RIVER
AT NORDEGG
JULY 10, 1969
Q = 11,900

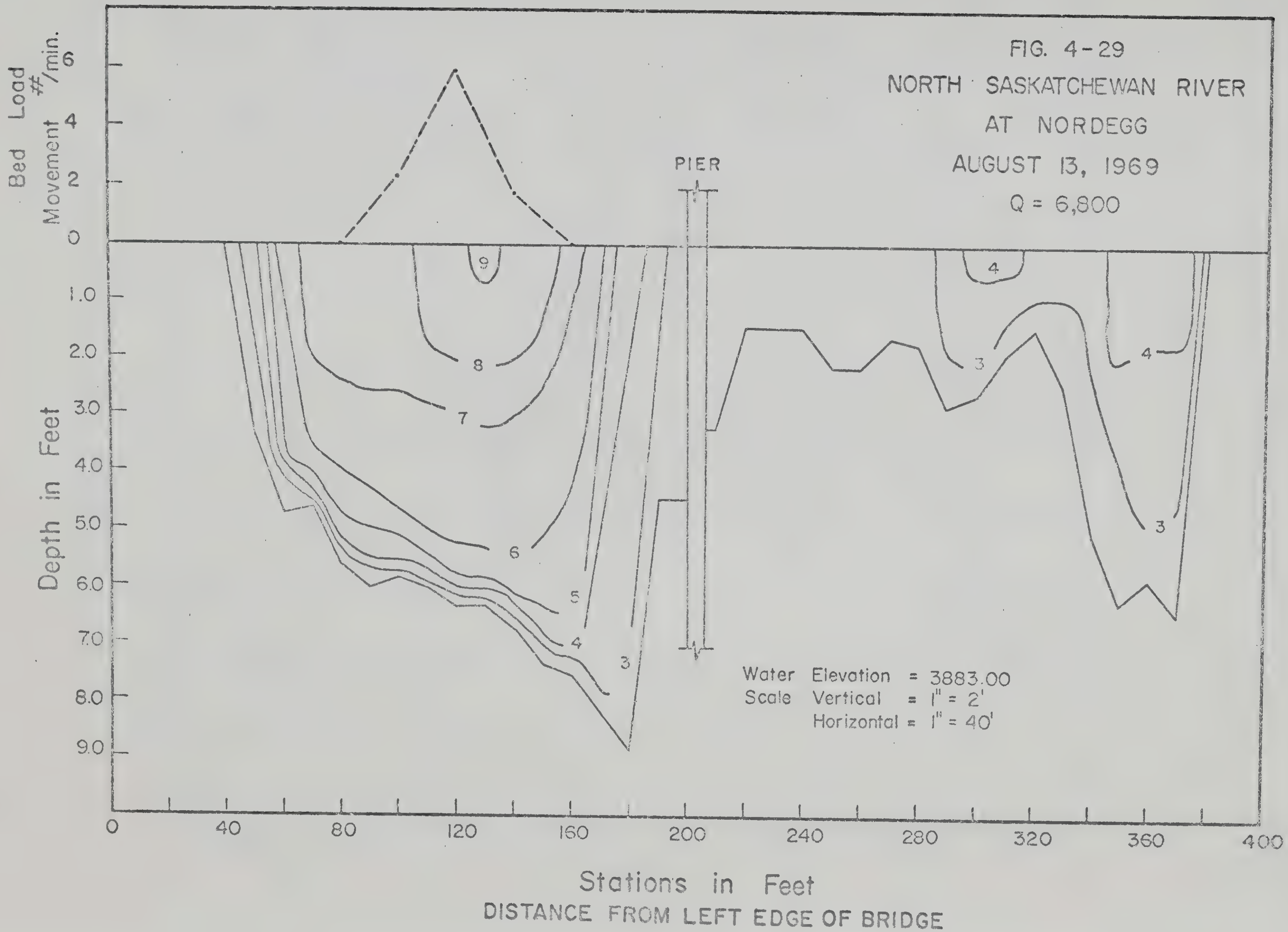


FIG. 4-29
NORTH SASKATCHEWAN RIVER
AT NORDEGG
AUGUST 13, 1969
Q = 6,800
Bed Load Movement #/min.
Depth in Feet
PIER
9
8
7
6
5
4
3
Water Elevation = 3883.00
Scale Vertical = 1" = 2'
Horizontal = 1" = 40'
Stations in Feet
DISTANCE FROM LEFT EDGE OF BRIDGE

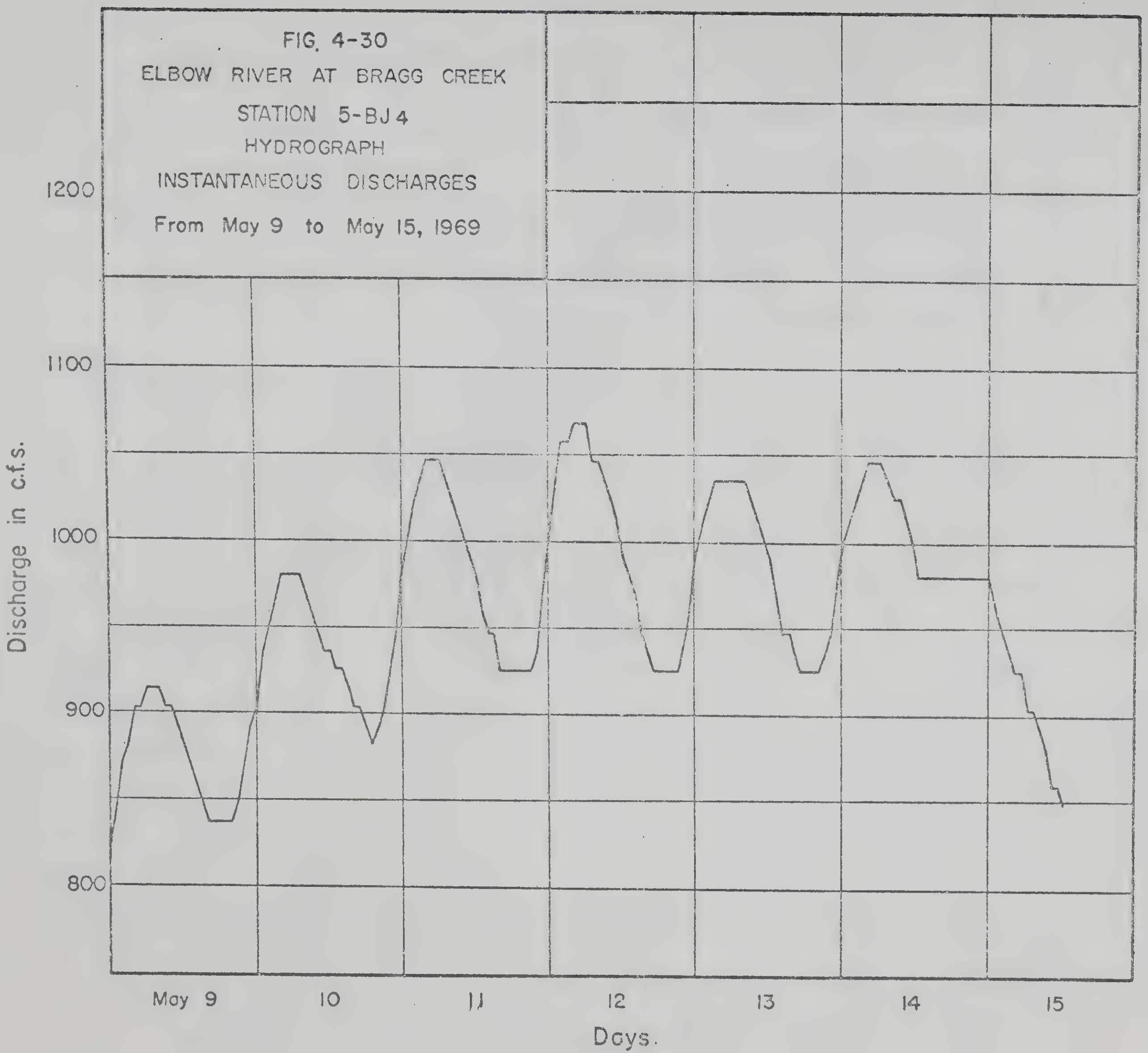


FIG. 4-30
ELBOW RIVER AT BRAGG CREEK
STATION 5-BJ4
HYDROGRAPH
INSTANTANEOUS DISCHARGES
From May 9 to May 15, 1969
1200
1100
1000
900
800
Discharge in c.f.s.
May 9
10
11
12
13
14
15
Days.

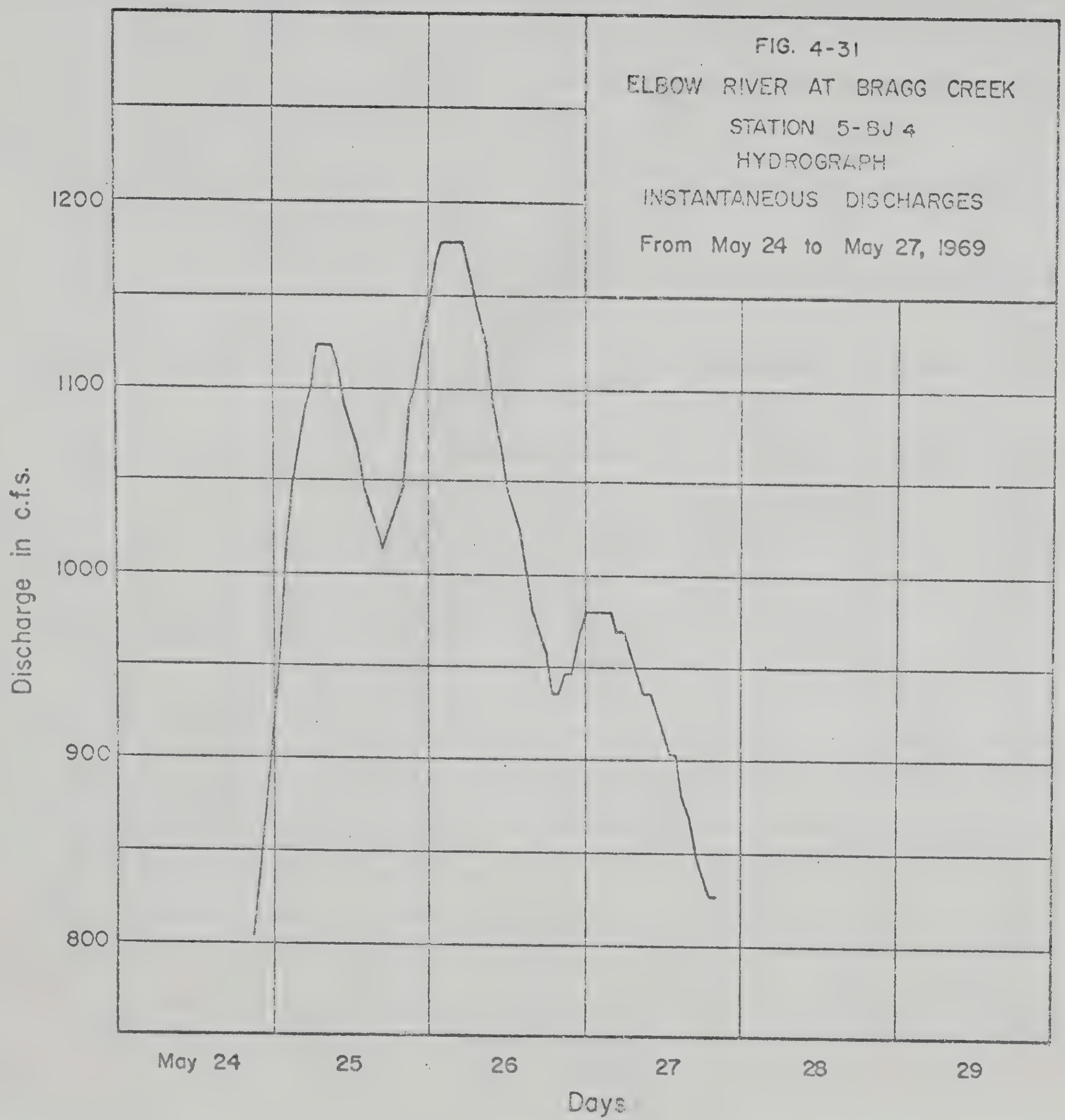


FIG. 4-31
ELBOW RIVER AT BRAGG CREEK
STATION 5-BJ 4
HYDROGRAPH
INSTANTANEOUS DISCHARGES
From May 24 to May 27, 1969
Discharge in c.f.s.
1200
1100
1000
900
800
May 24
25
26
27
28
29
Days

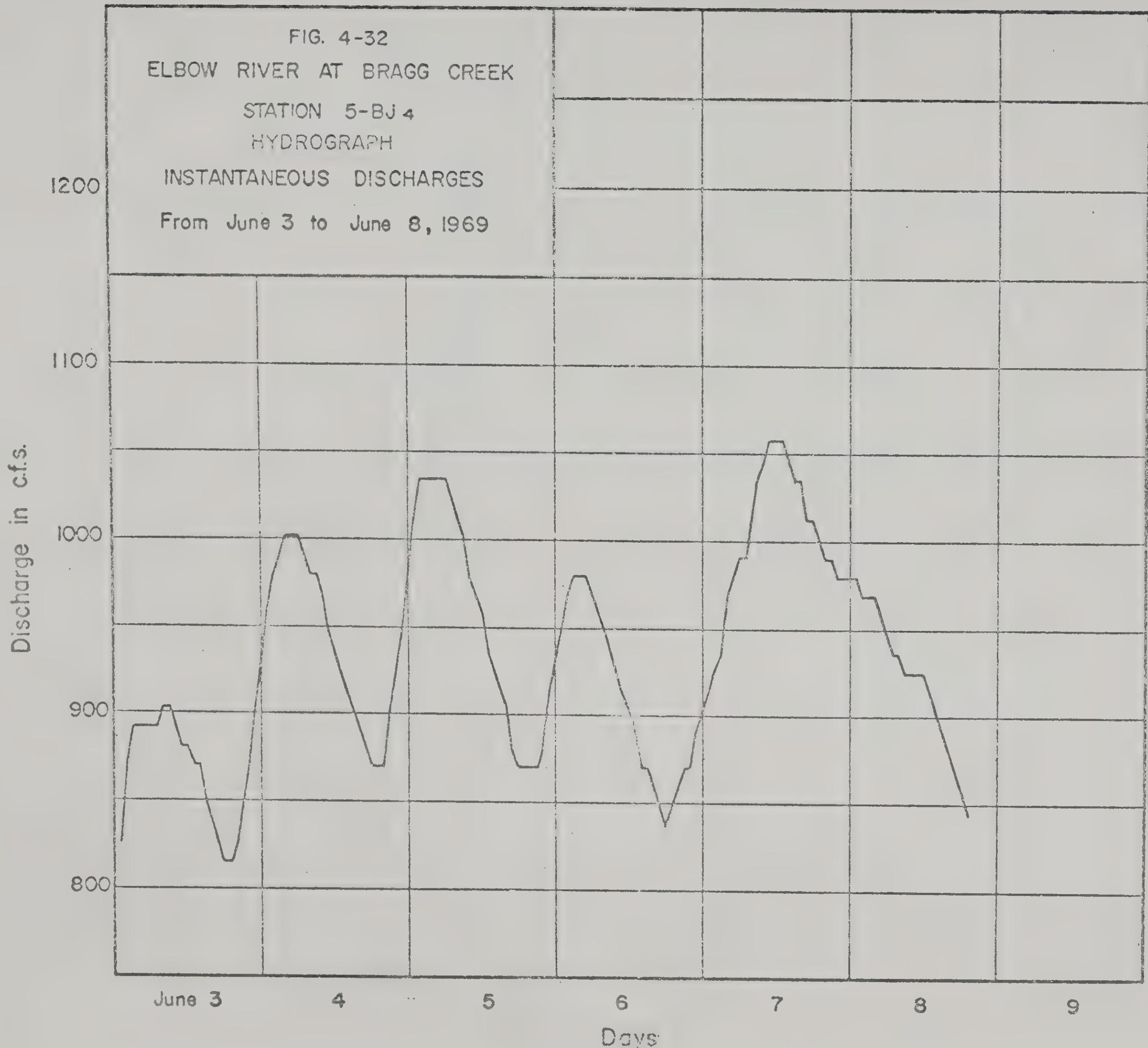


FIG. 4-32
ELBOW RIVER AT BRAGG CREEK
STATION 5-BJ 4
HYDROGRAPH
INSTANTANEOUS DISCHARGES
From June 3 to June 8, 1969

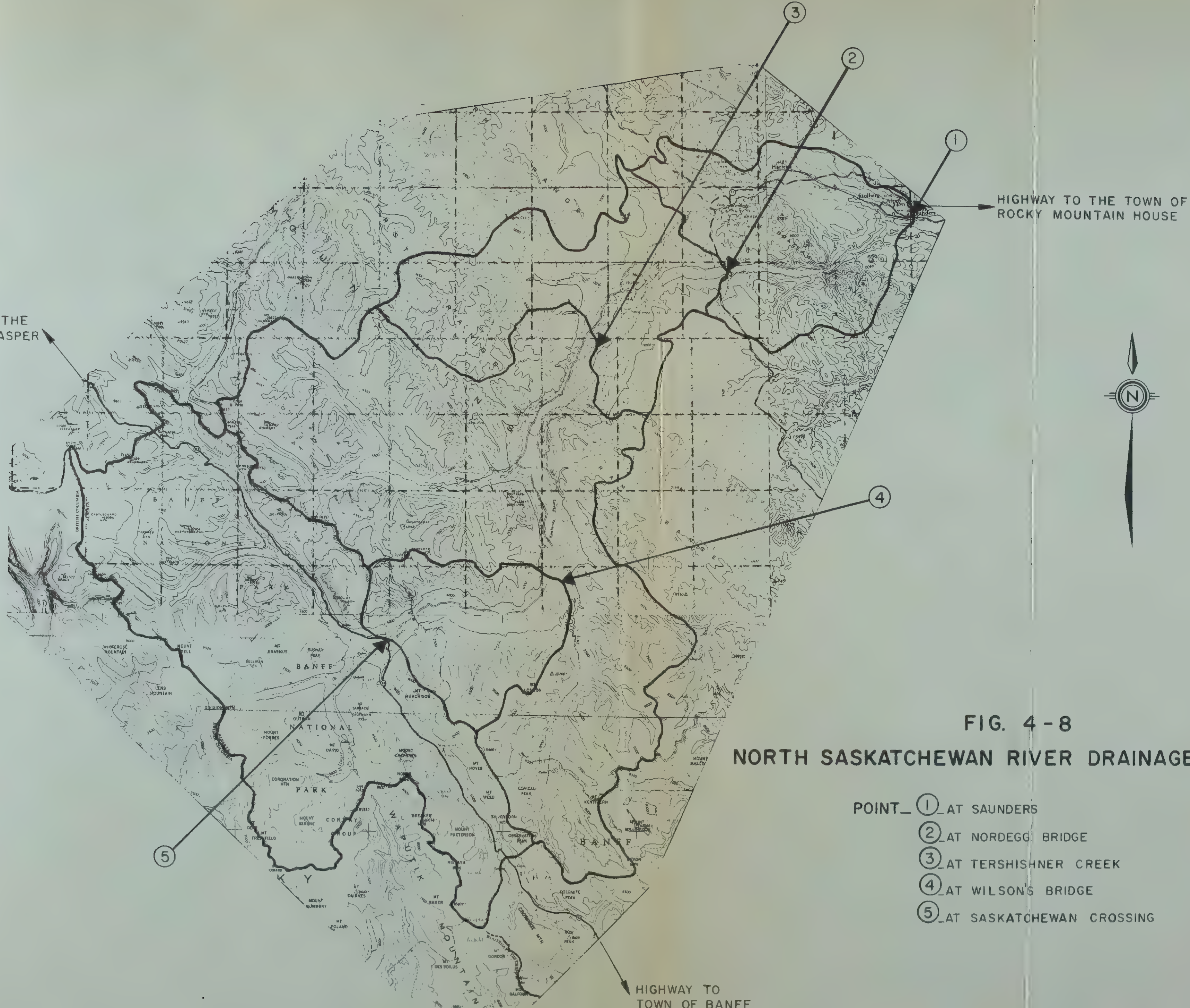


FIG. 4-8

NORTH SASKATCHEWAN RIVER DRAINAGE BASIN

POINT_ (1)_AT SAUNDERS
(2)_AT NORDEGG BRIDGE
(3)_AT TERSHISHNER CREEK
(4)_AT WILSON'S BRIDGE
(5)_AT SASKATCHEWAN CROSSING

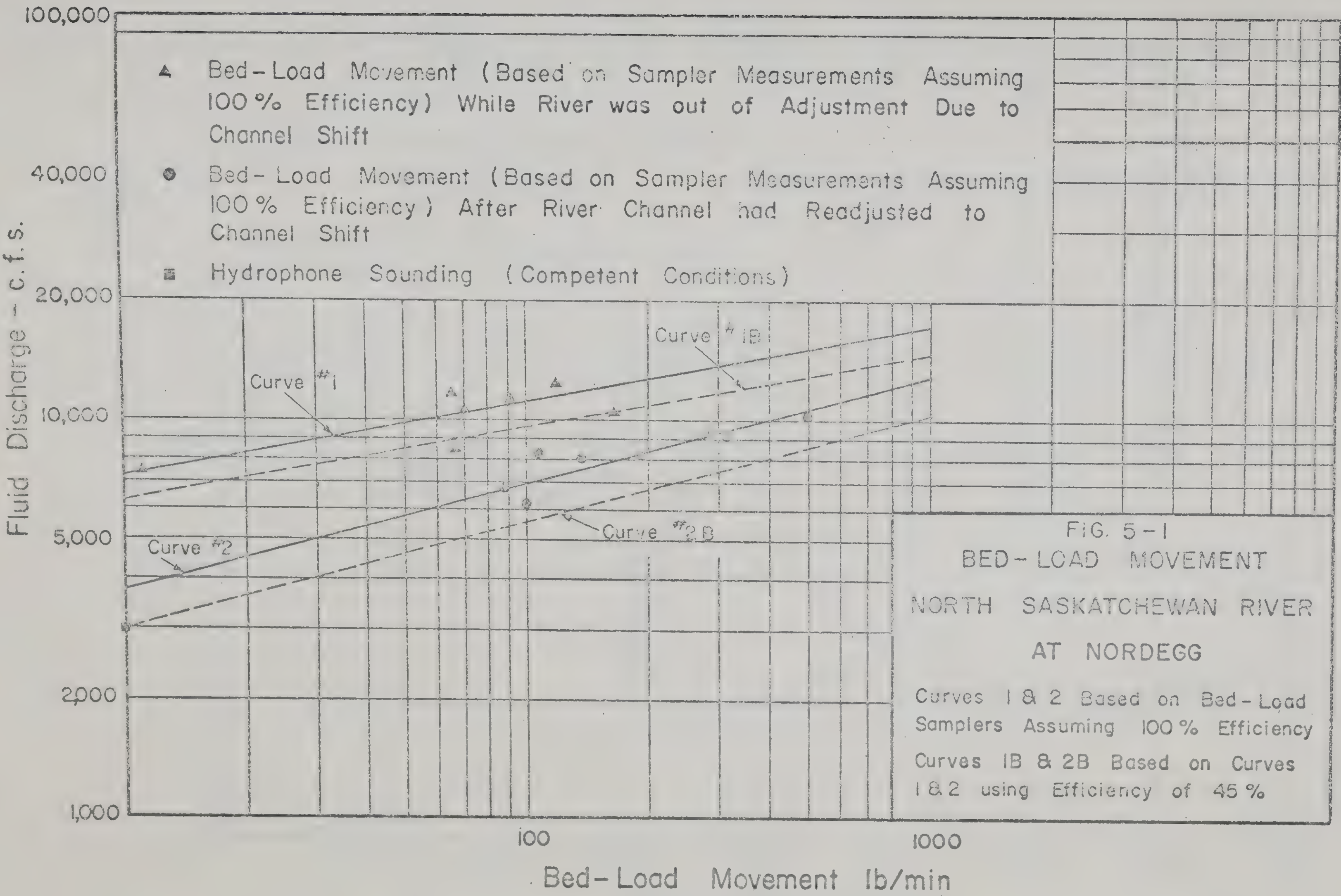


FIG. 5-1
BED-LOAD MOVEMENT
NORTH SASKATCHEWAN RIVER
AT NORDEGG

Curves 1 & 2 Based on Bed-Load Samplers Assuming 100 % Efficiency
Curves 1B & 2B Based on Curves 1 & 2 using Efficiency of 45 %

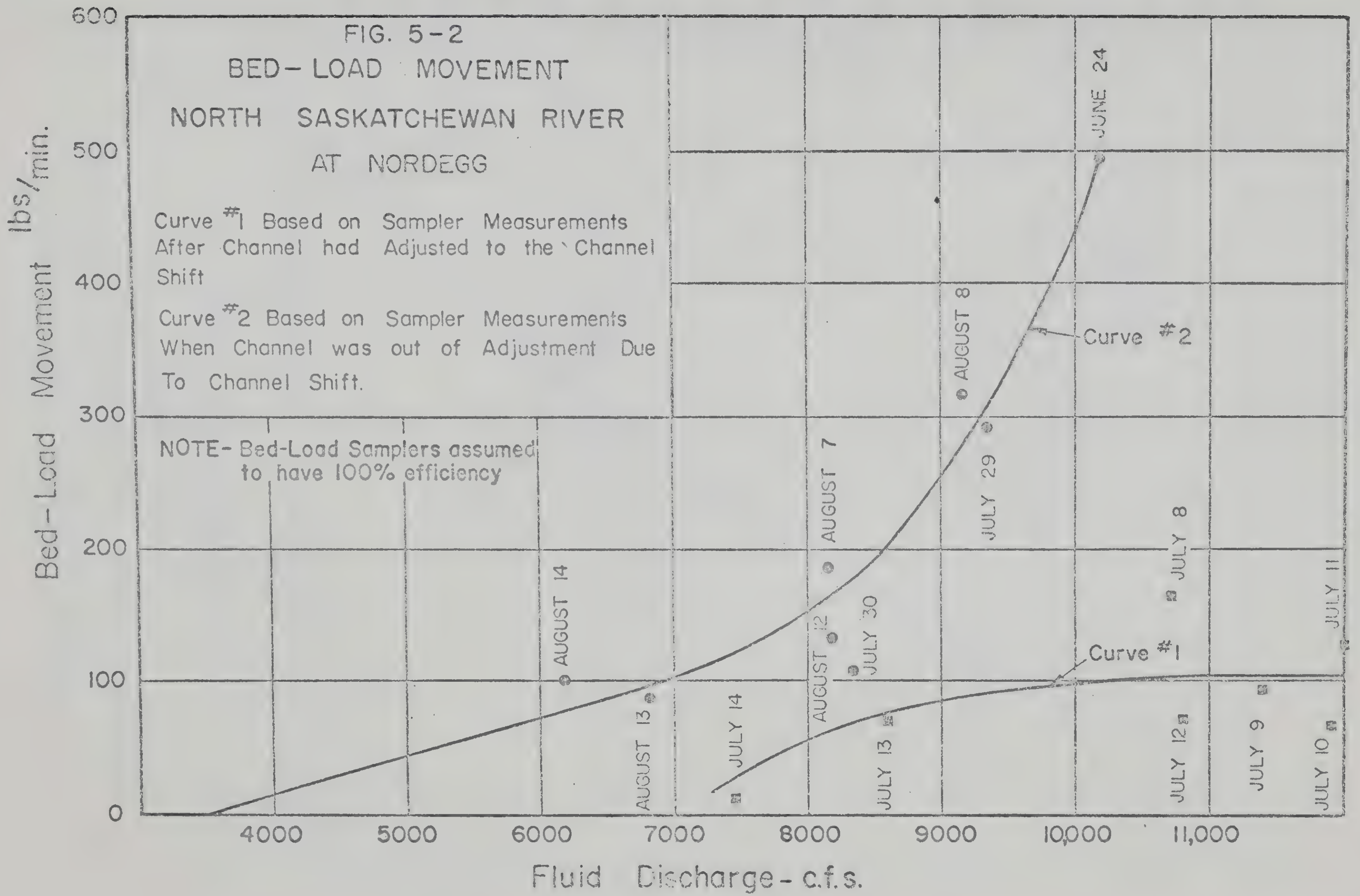


FIG. 5-2
BED-LOAD MOVEMENT
NORTH SASKATCHEWAN RIVER
AT NORDEGG
Curve #1 Based on Sampler Measurements After Channel had Adjusted to the Channel Shift
Curve #2 Based on Sampler Measurements When Channel was out of Adjustment Due To Channel Shift.
NOTE- Bed-Load Samplers assumed to have 100% efficiency
Bed-Load Movement lbs/min.
600
500
400
300
200
100
0
4000
5000
6000
7000
8000
9000
10,000
11,000
Fluid Discharge - c.f.s.
Curve #1
Curve #2
JUNE 24
AUGUST 8
AUGUST 7
JULY 29
JULY 8
AUGUST 14
AUGUST 12
JULY 30
JULY 11
AUGUST 13
JULY 14
JULY 13
JULY 12
JULY 9
JULY 10

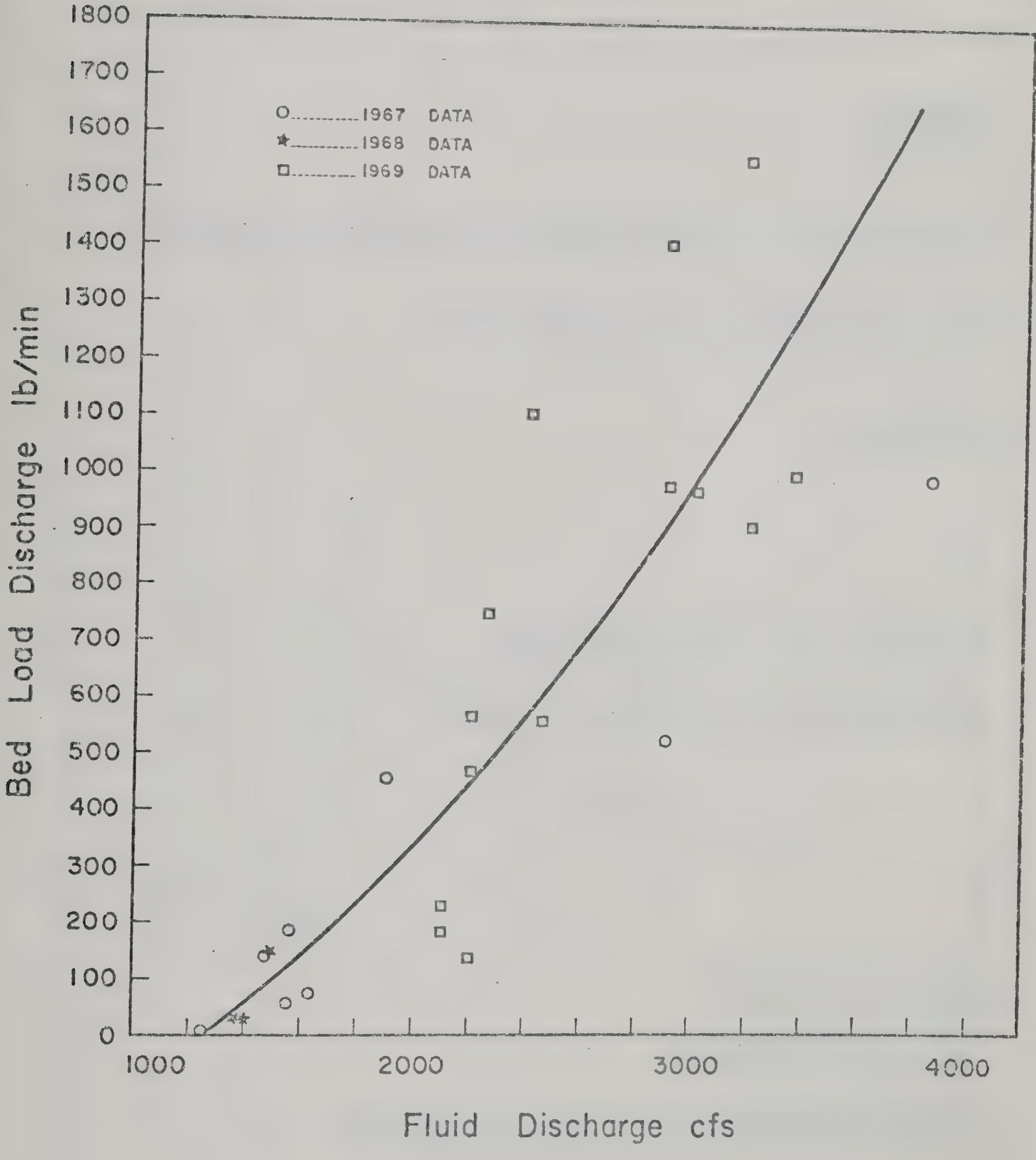


FIG. 5-3-A

BED LOAD DISCHARGE Vs FLUID DISCHARGE

ELBOW RIVER AT BRAGG CREEK

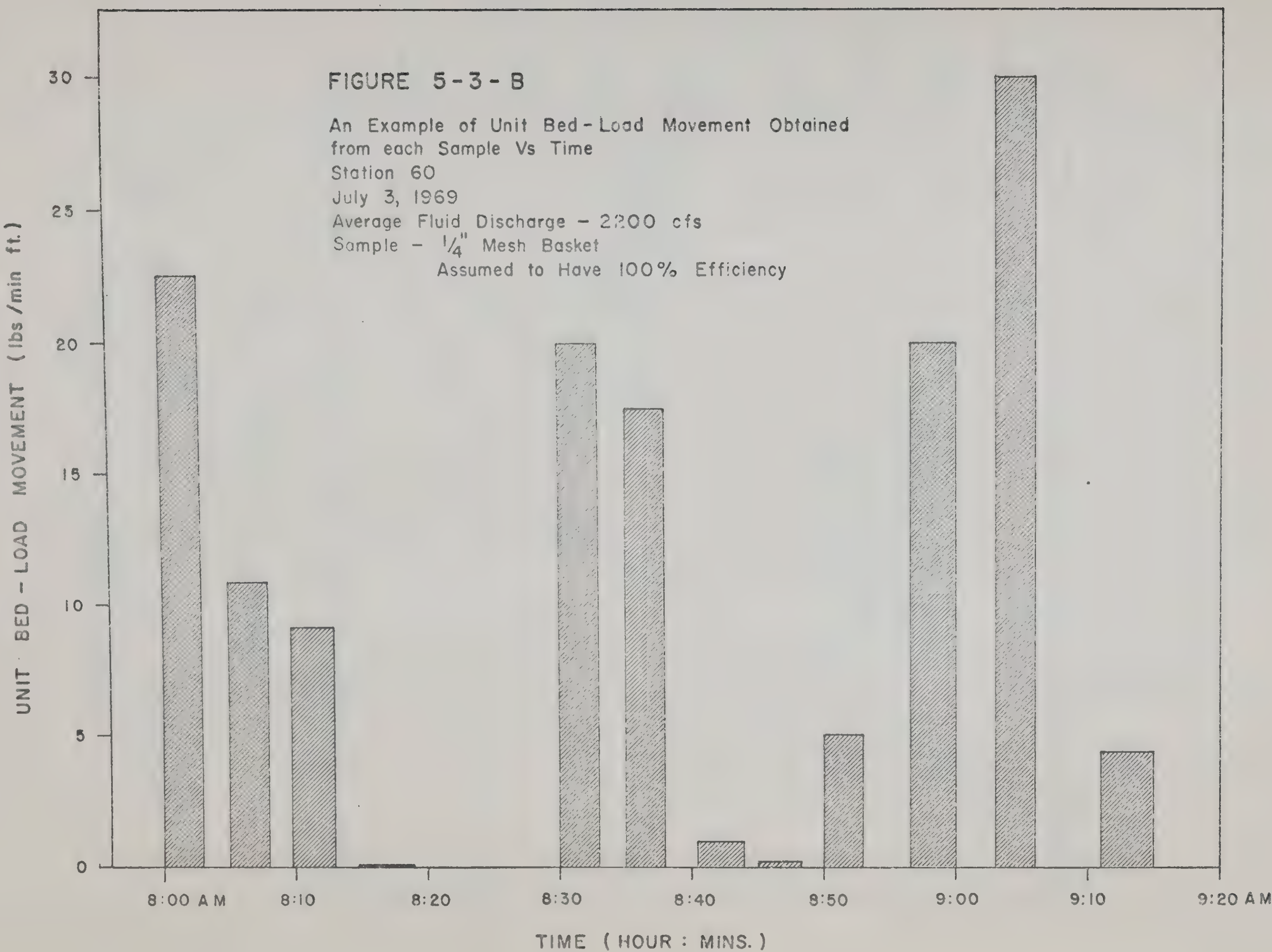


FIGURE 5-3-B

An Example of Unit Bed-Load Movement Obtained from each Sample Vs Time
Station 60
July 3, 1969
Average Fluid Discharge – 2200 cfs
Sample – 1/4" Mesh Basket
Assumed to Have 100% Efficiency

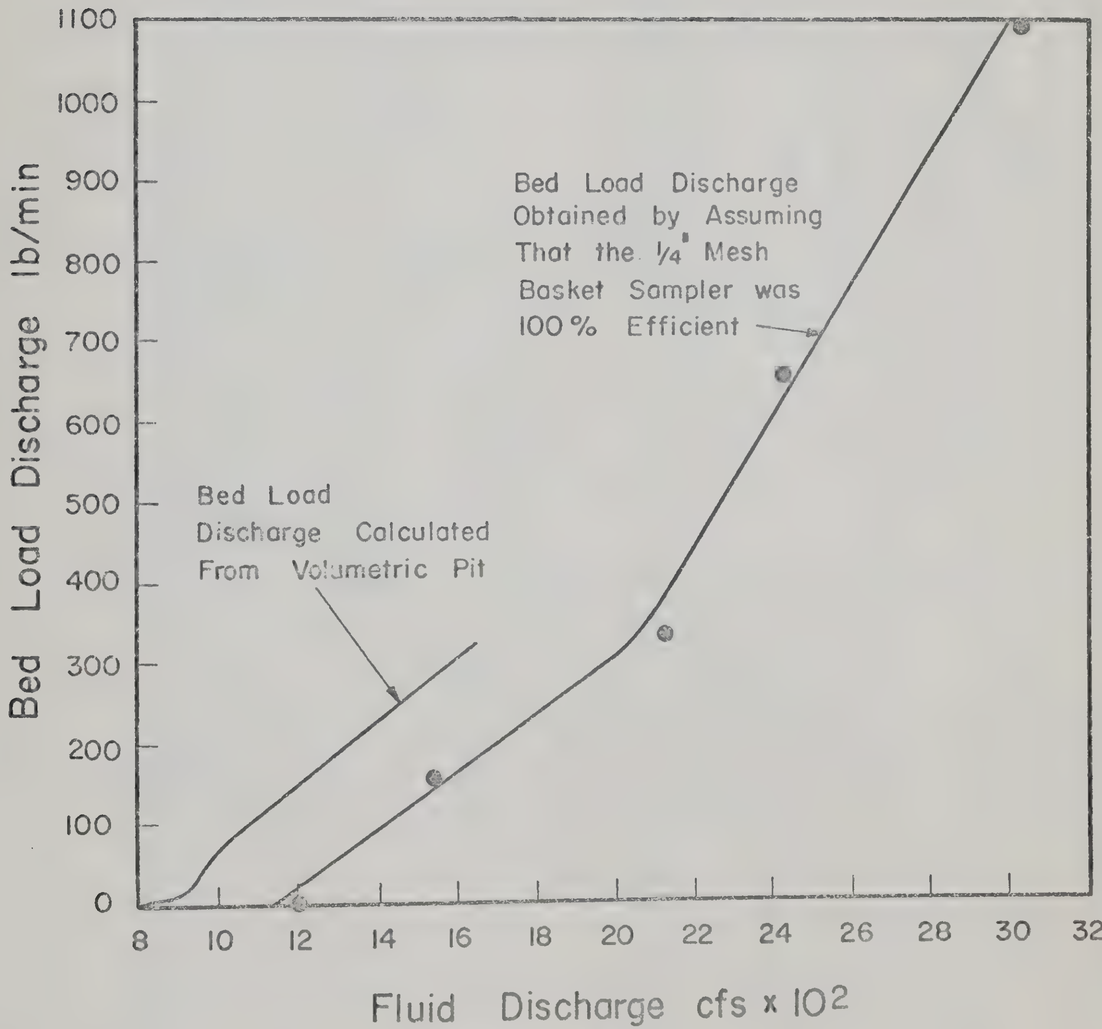


FIG 5-3-C

BED LOAD DISCHARGE Vs FLUID DISCHARGE

ELBOW RIVER AT BRAGG CREEK

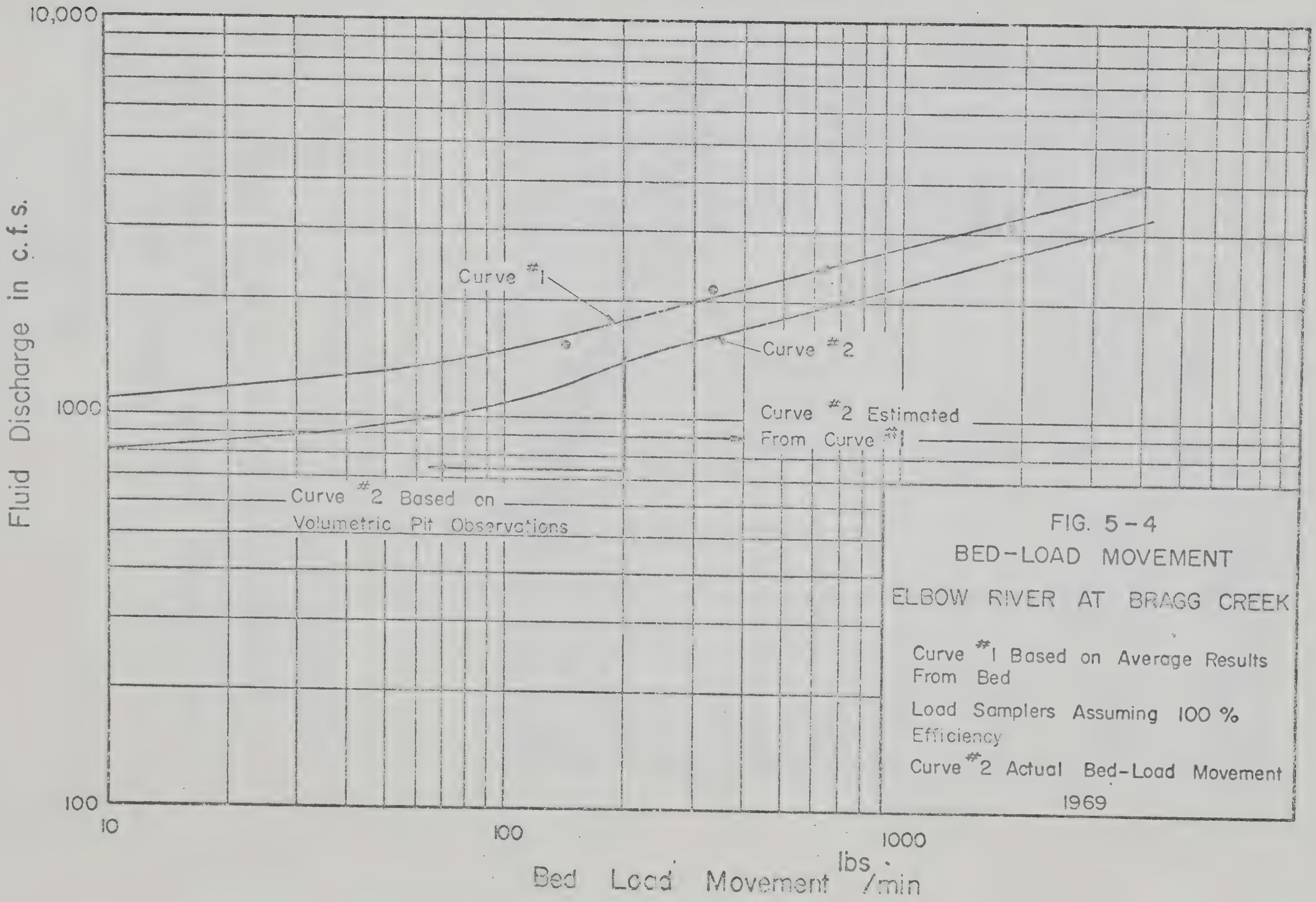


FIG. 5-4
BED-LOAD MOVEMENT
ELBOW RIVER AT BRAGG CREEK

Curve #1 Based on Average Results From Bed Load Samplers Assuming 100 % Efficiency

Curve #2 Actual Bed-Load Movement

1969

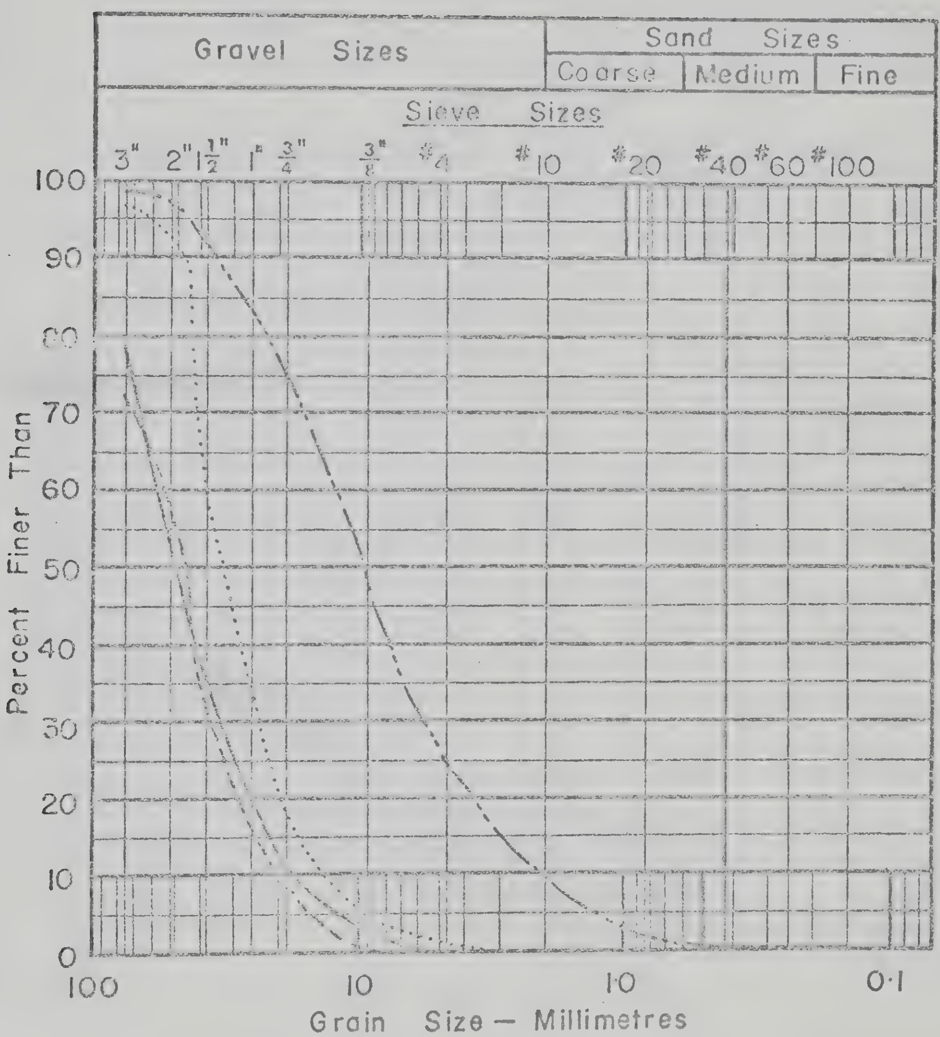


FIG. 5 - 5

Grain Size Curves for Stations 50, 60, 70 & 80

Elbow River at Bragg Creek 1969

Based on Bed-Load discharge sampled with ¼" mesh Basket Sampler

LEGEND

-·-·-·- Station 50

·········· Station 60

———— Station 70

– – – – – Station 80

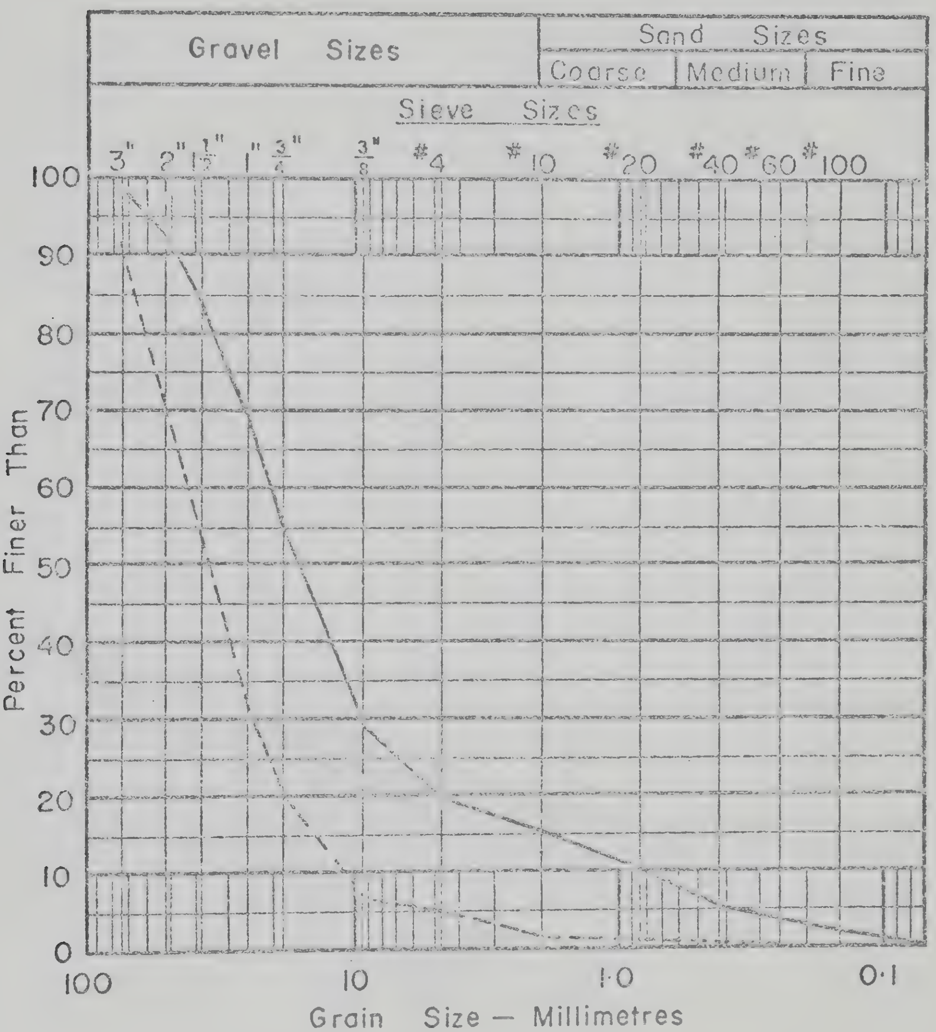


FIG. 5-6

Grain Size Curves for Stations 50 & 70

Elbow River at Bragg Creek 1969

Based on Bed-Load material derived from Volumetric Pit.

——— Station 50
- - - - Station 70

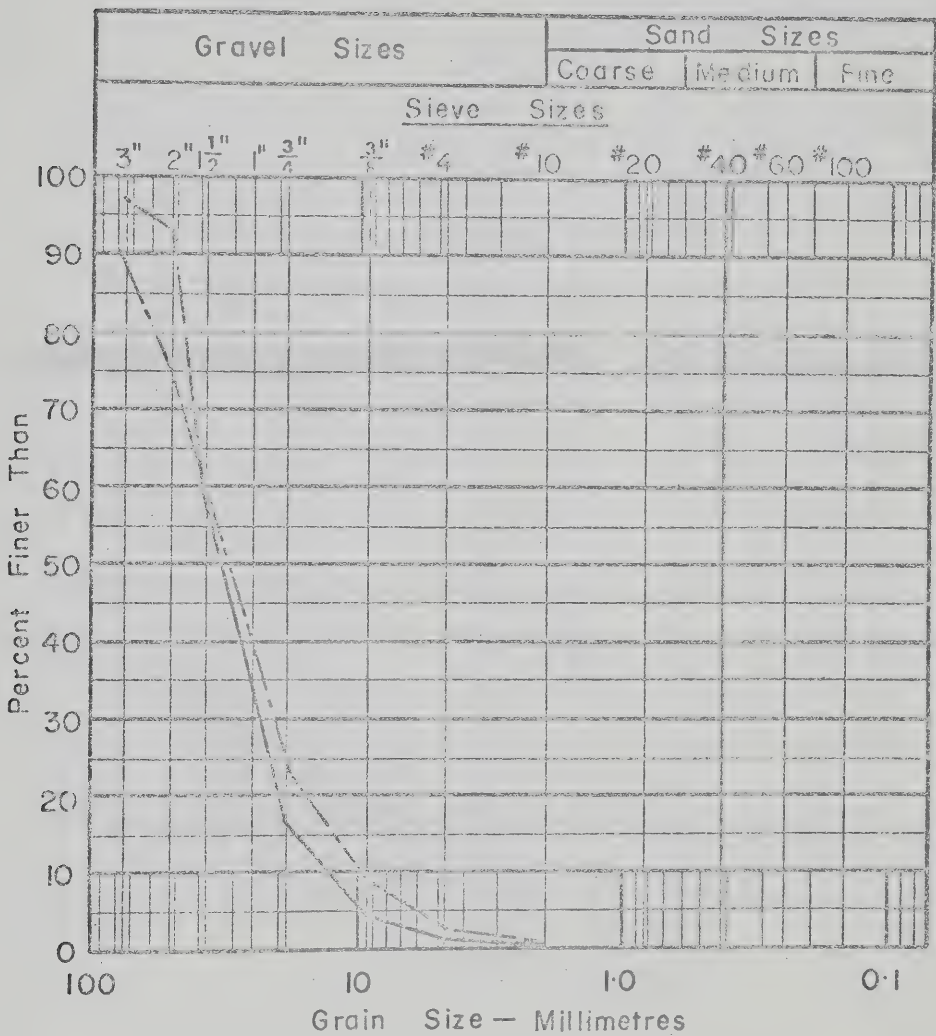


FIG. 5-8

Grain Size Curves for Station 60

Elbow River at Bragg Creek 1969

Based on Bed-Load discharge sampled with VUV & ¼" mesh Basket Samplers.

——— Station 60 ¼" mesh Basket

-·-·-· Station 60 VUV

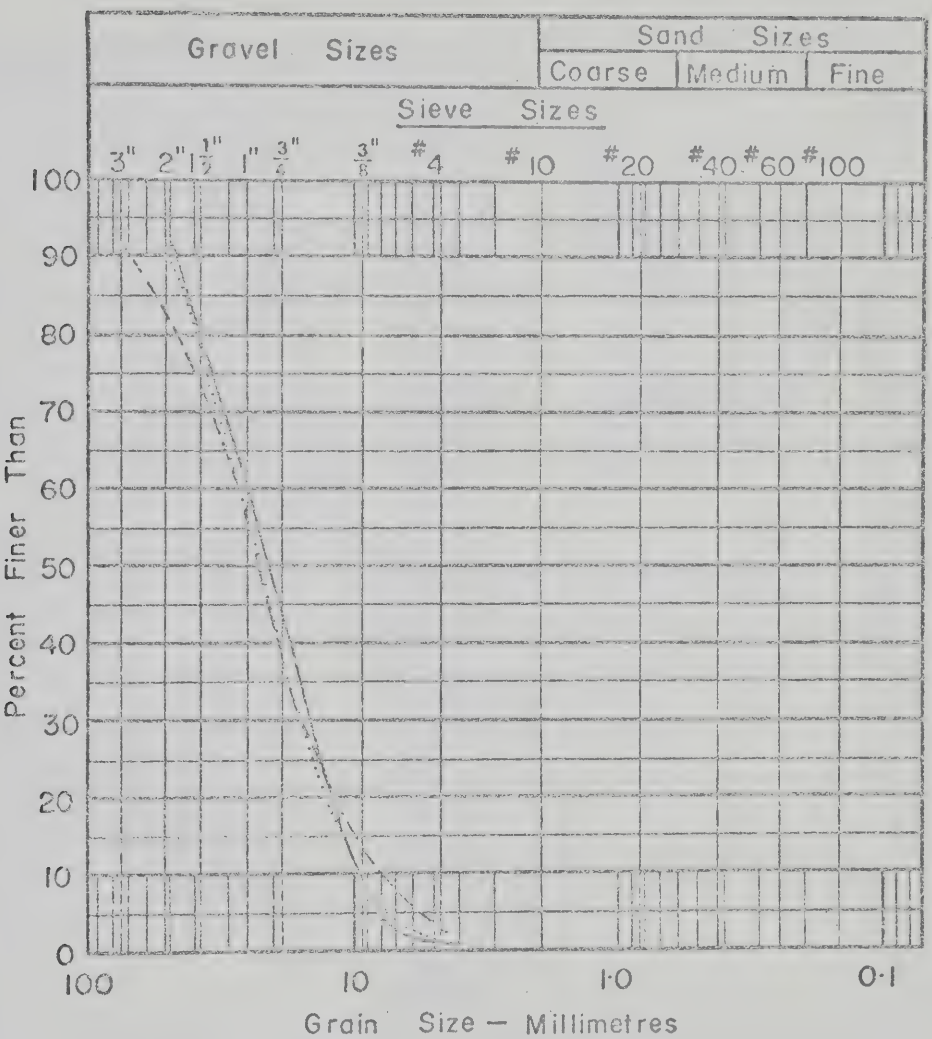


FIG. 5-10

Grain Size Curves for Station 120

North Saskatchewan River at Nordegg

Period from July 29 to July 31, 1969

.... Average of all ¼" mesh Basket Samples

——— Average of all ½" mesh Basket Samples

------ Average of all VUV Samples

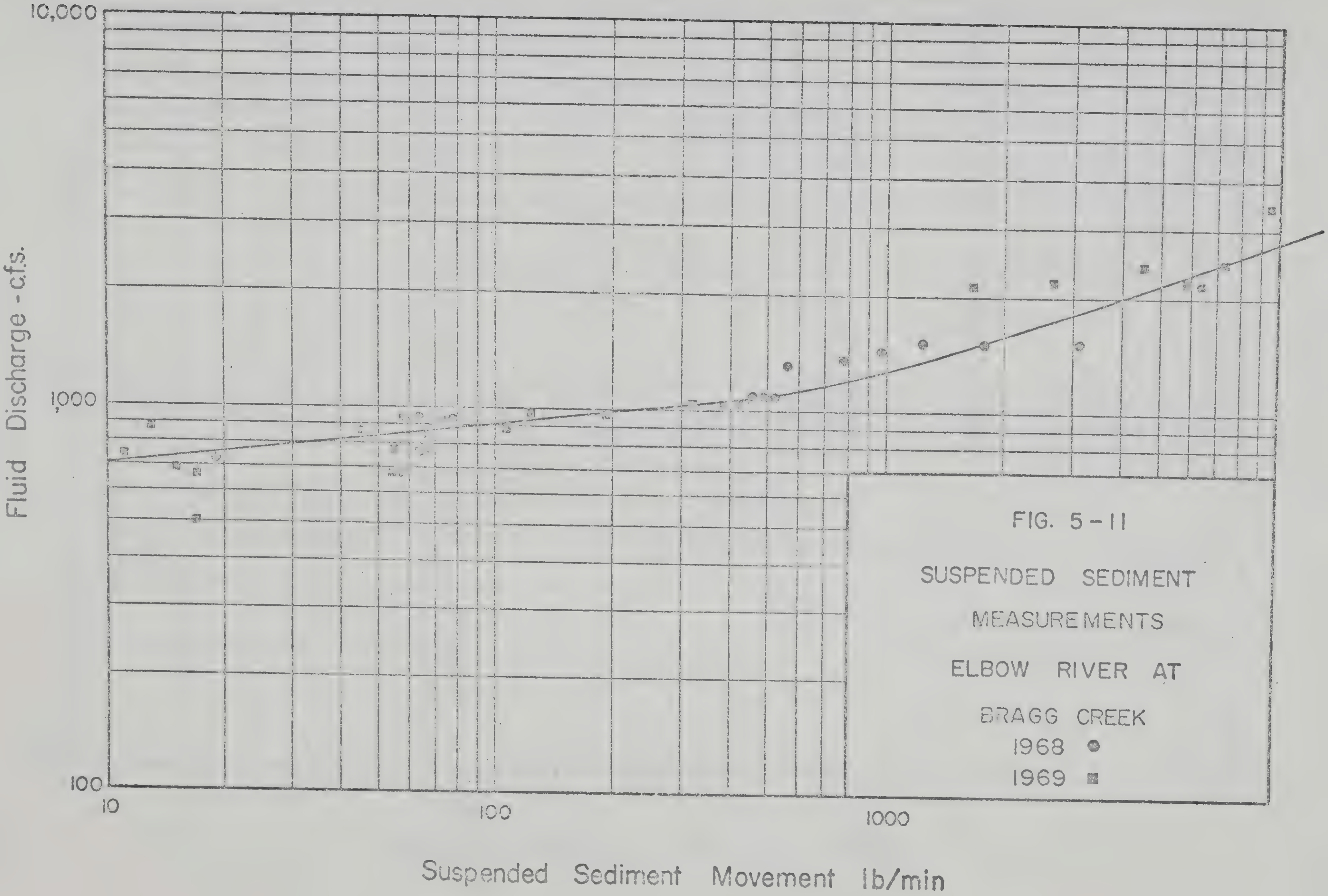


FIG. 5-11

SUSPENDED SEDIMENT MEASUREMENTS ELBOW RIVER AT BRAGG CREEK

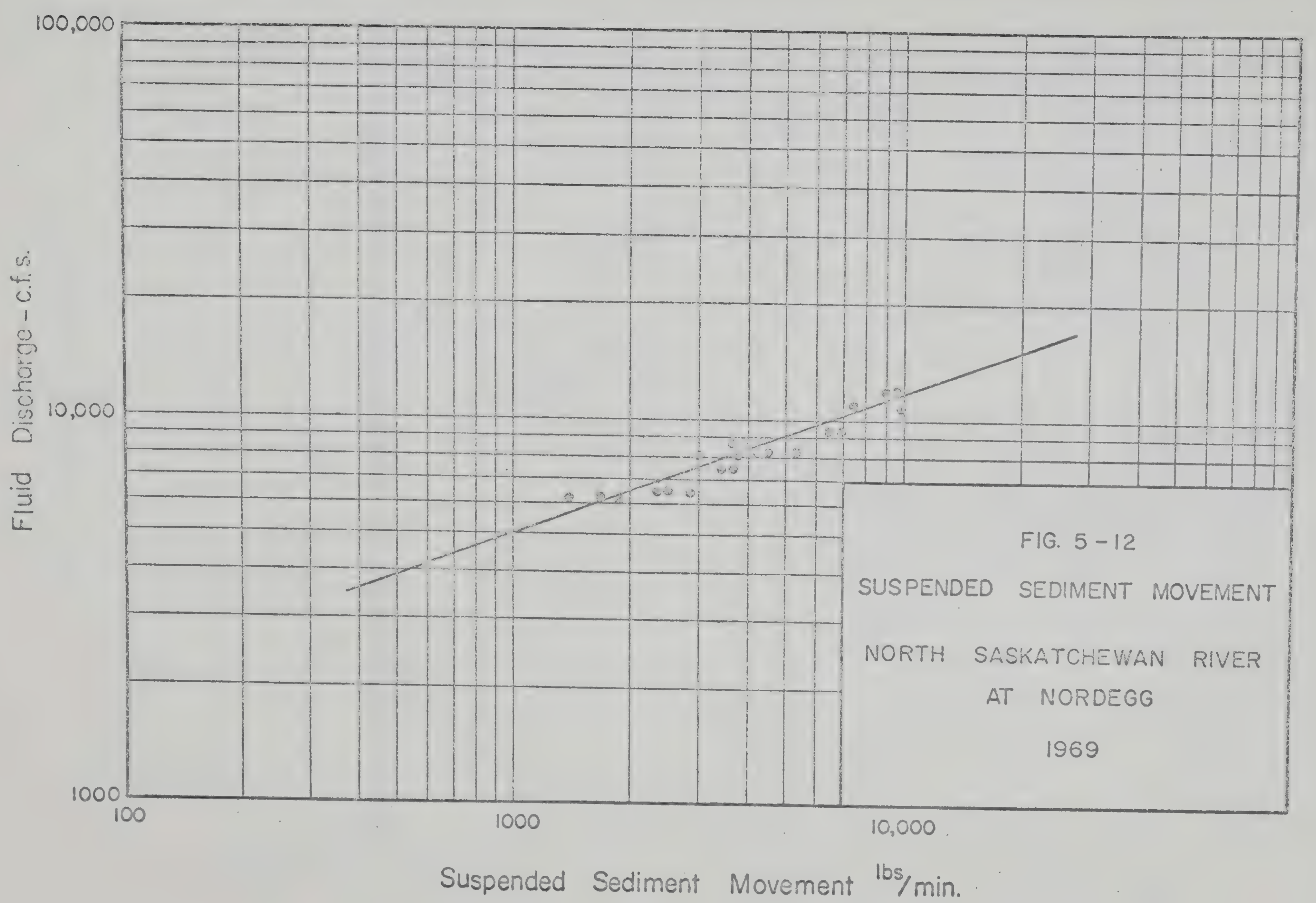


FIG. 5 - 12

SUSPENDED SEDIMENT MOVEMENT

NORTH SASKATCHEWAN RIVER
AT NORDEGG

1969

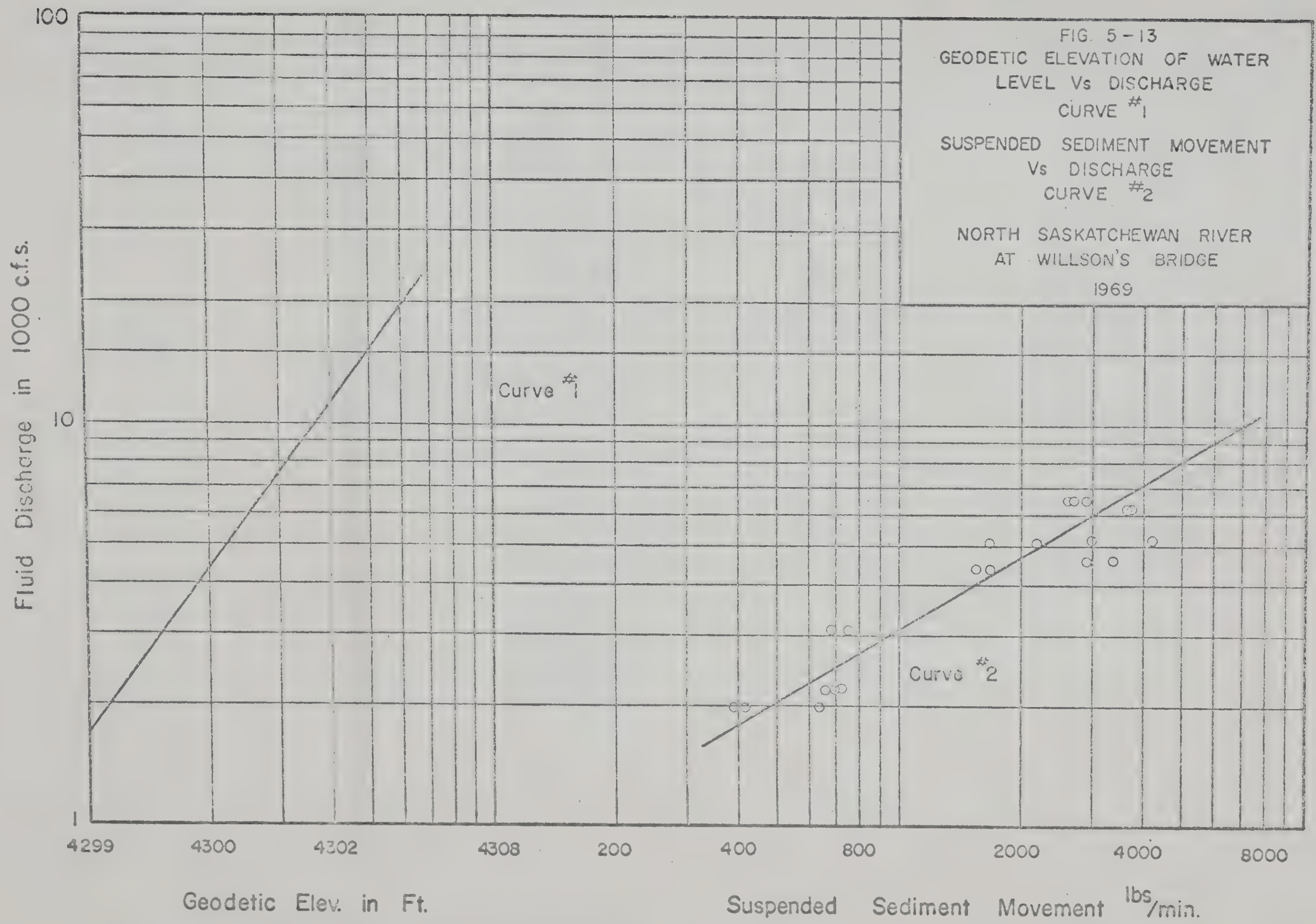


FIG. 5 - 13
GEODETIC ELEVATION OF WATER LEVEL Vs DISCHARGE CURVE #1
SUSPENDED SEDIMENT MOVEMENT Vs DISCHARGE CURVE #2
NORTH SASKATCHEWAN RIVER AT WILLSON'S BRIDGE
1969
Curve #1
Curve #2
100
10
1
Fluid Discharge in 1000 c.f.s.
4299
4300
4302
4308
200
400
800
2000
4000
8000
Geodetic Elev. in Ft.
Suspended Sediment Movement lbs/min.

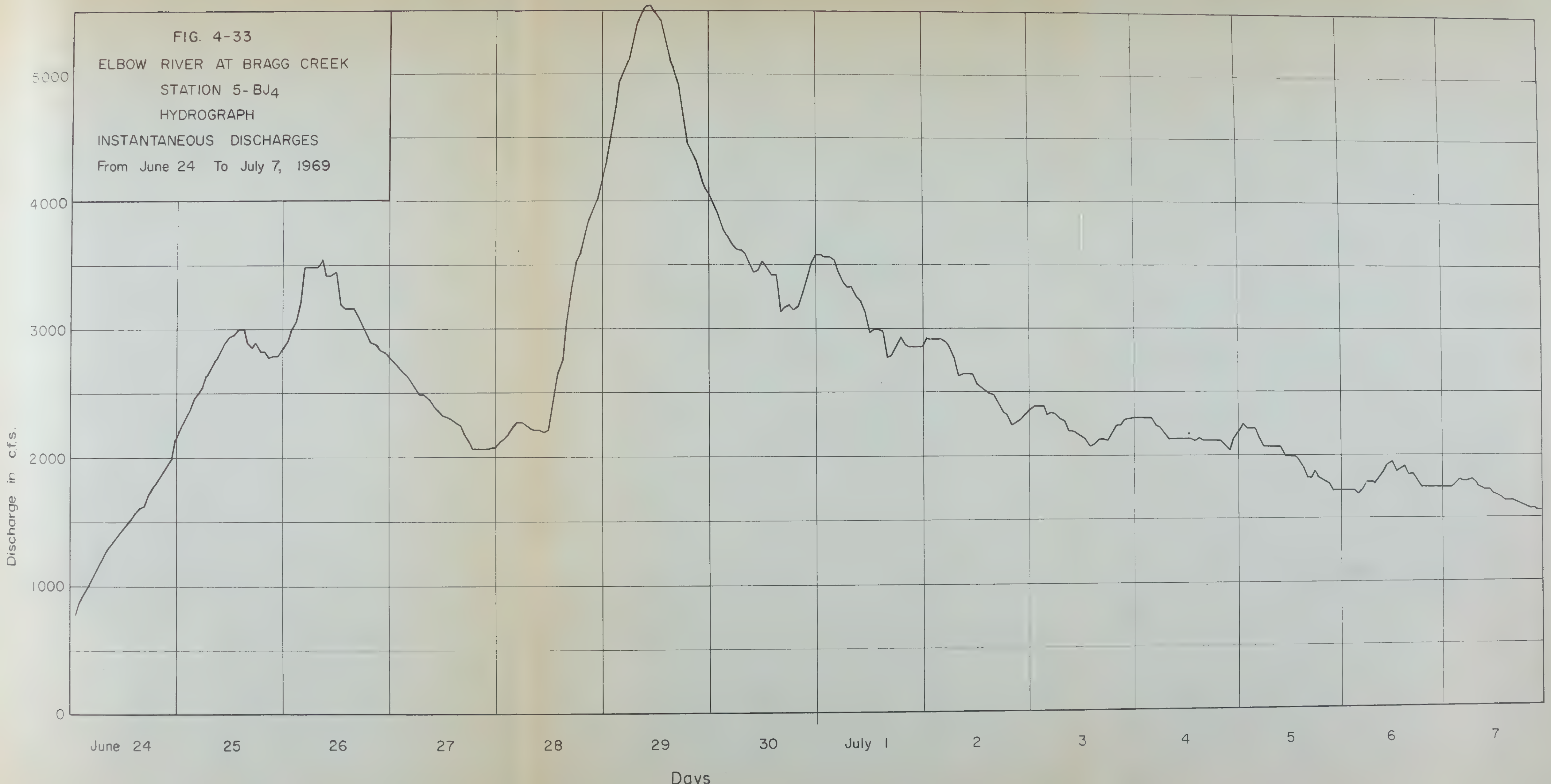


FIG. 4-33
ELBOW RIVER AT BRAGG CREEK
STATION 5-BJ4
HYDROGRAPH
INSTANTANEOUS DISCHARGES
From June 24 To July 7, 1969
Discharge in c.f.s.
5000
4000
3000
2000
1000
0
June 24
25
26
27
28
29
30
July 1
2
3
4
5
6
7
Days

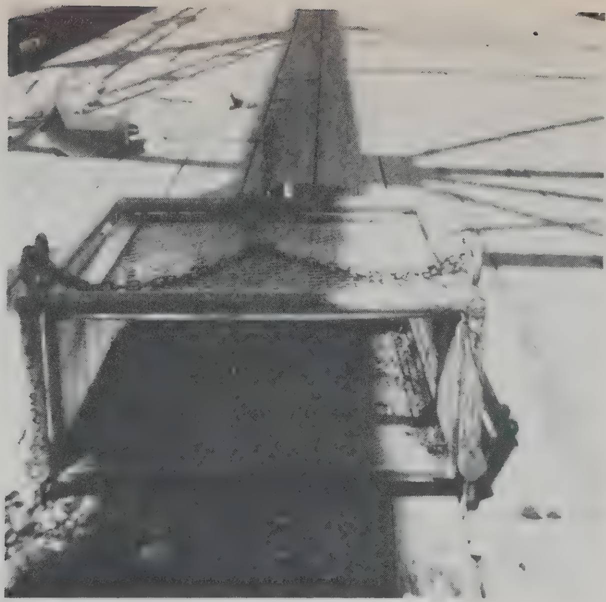


PLATE # 111-1
Large Basket Sampler

PLATE # 111-2
Large V.U.V. Sampler

APPENDIX C

PHOTOGRAPHS

PLATE # 111-3
Cable Car used for Bed Load Sampling
at Bragg Creek

PLATE # 111-4
Power Winch used for raising and lowering
Bed Load Samplers

PLATE # 111-5

Power winch used for moving back and forth on cableway

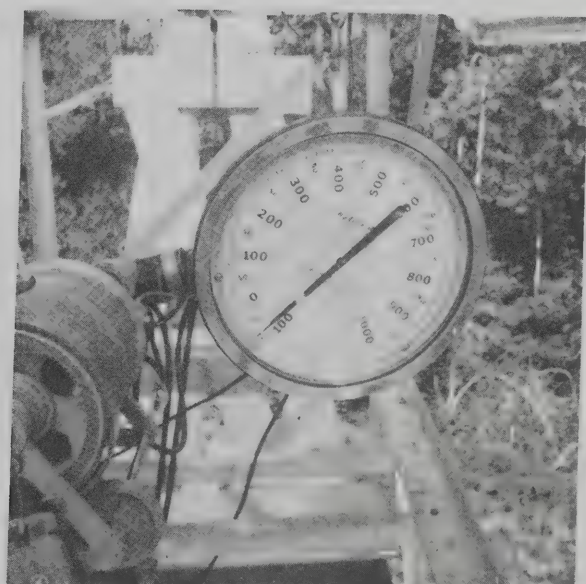


PLATE # 111-6

Scale used for weighing Bed Load Samples

PLATE #111-7

Stay Line at Bragg Creek

PLATE # 111-8

Sampling Truck with Crane fully extended

PLATE # 111-9

Full size V.U.V. Sampler being lowered into the North Saskatchewan River.

PLATE # 111-10

Full size V.U.V. Sampler just before entry into water. Notice how tightening the rear rope tilts the sampler mouth downward. This tilting enables the sampler to plane its way to the river bottom.

PLATE # 111-11

Full Size V.U.V. Sampler being raised from the water. Note that the rear rope is slack.

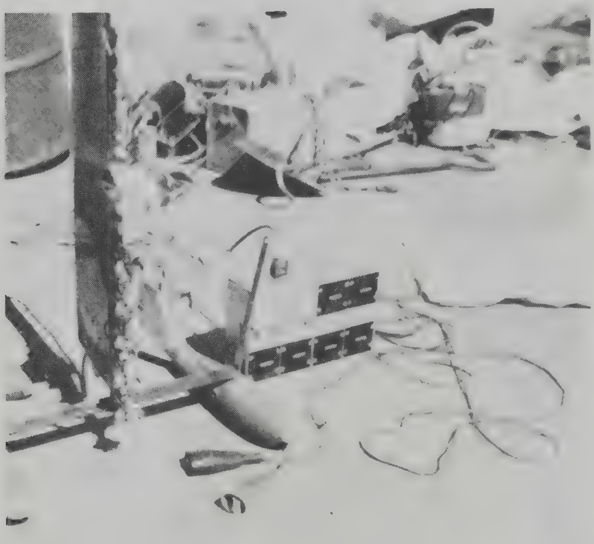


PLATE # 111-12

Velocity rake

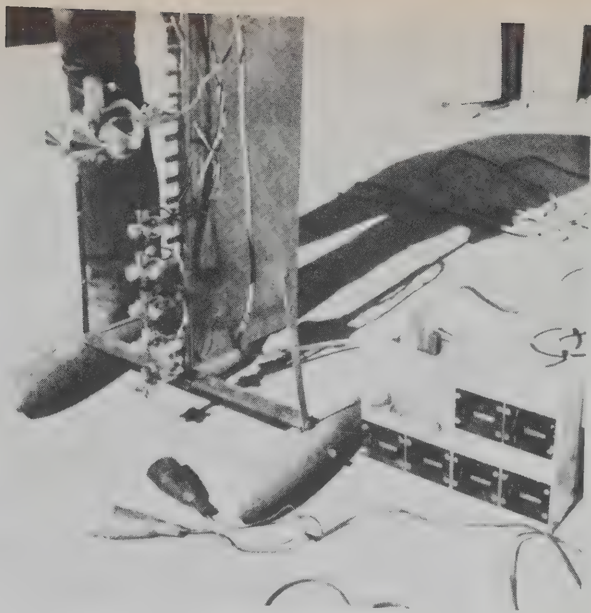


PLATE #111-13

Velocity Rake

PLATE # 111-14

US D-49 Depth-Integrating Sampler

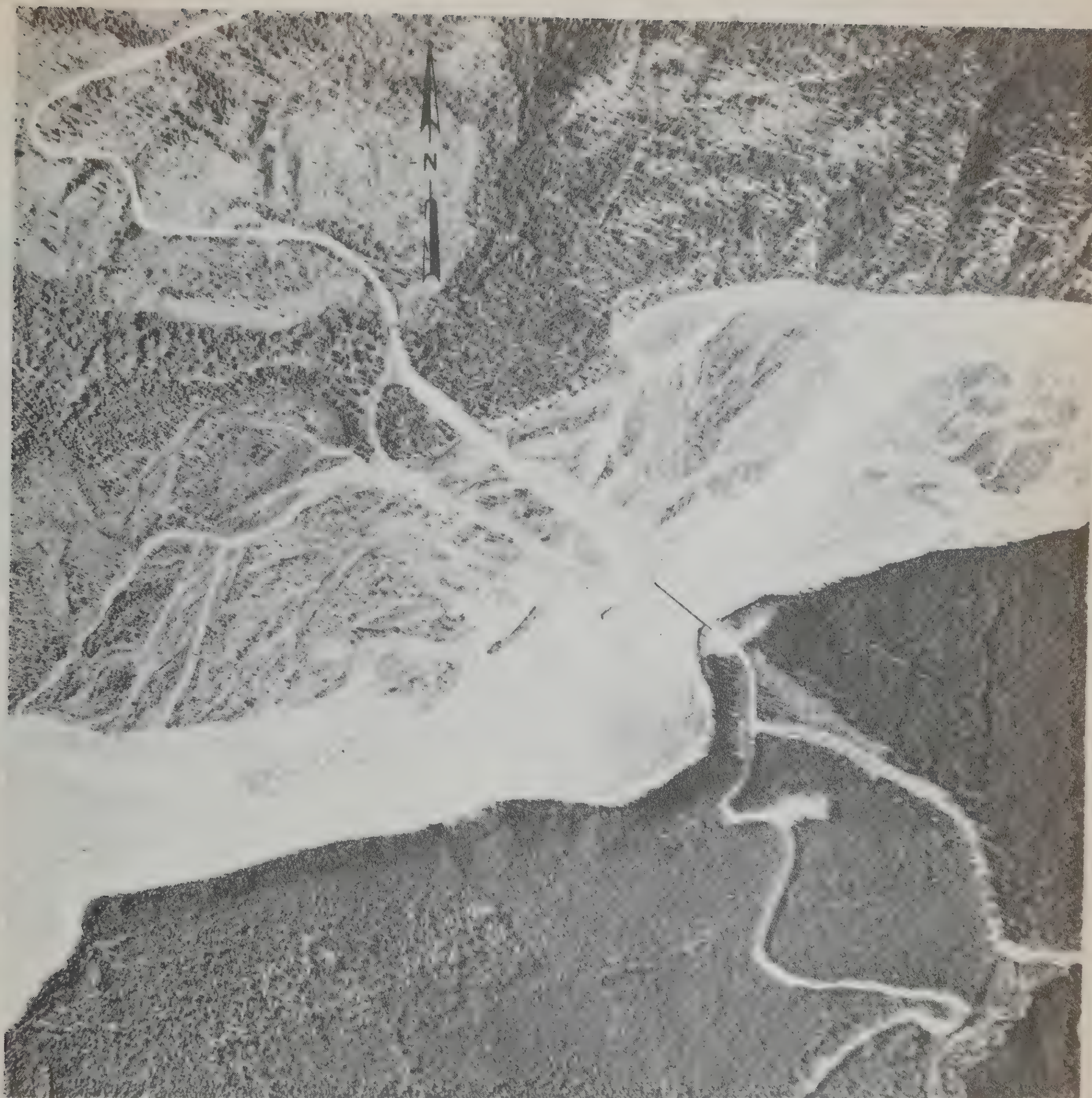


PLATE # IV-1

Aerial View of North Saskatchewan River
at Nordegg Bridge

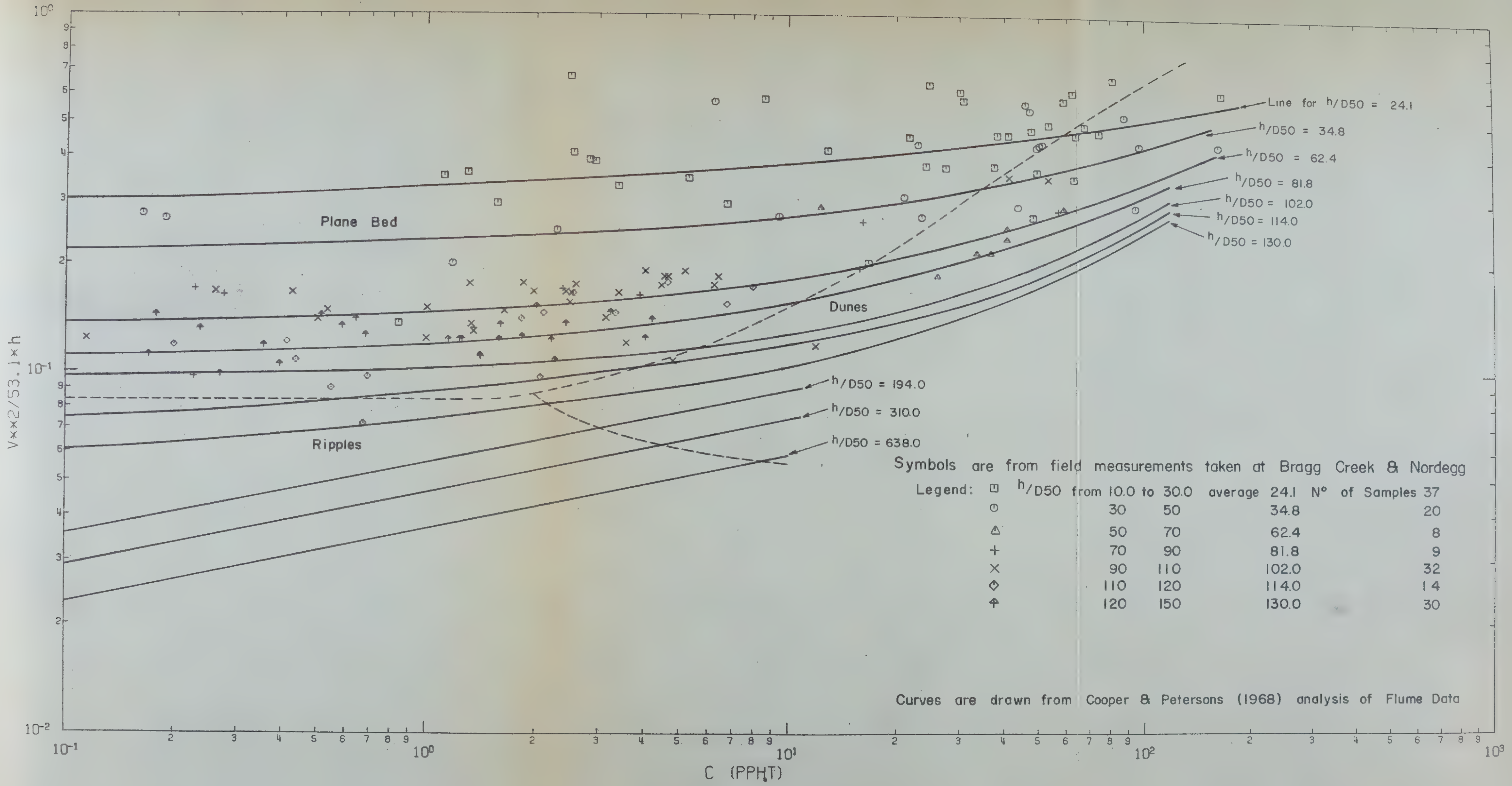


FIG.5-14 Relationship Between $Vm^2/(Gs-1)\,gh$, $h/D50$ & C

PLATE IV-2

Series of photographs taken from left Guide Bank in 1968
North Saskatchewan River at Nordegg

PLATE IV-3

Series of photographs taken from Left Guide Bank in 1969 North Saskatchewan River at Nordegg